NEW DAYLIGHT TECHNOLOGIES FOR SUSTAINABLE DESIGN
CASE STUDY - MOTHER TEREZA HOSPITAL IN TIRANA

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NEW DAYLIGHTING TECHNOLOGIES FOR SUSTAINABLEARCHITECTURAL DESIGN CASE STUDY: TIRANA

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ABSTRACT

NEW DAYLIGHTING TECHNOLOGIES FOR SUSTAINABLEARCHITECTURAL DESIGN CASE STUDY: TIRANA

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Public hospitals in Albania are mostly inherited from the communist period and are typically build as thick massive blocks due to the urgent building needs at that period. Most of the working areas and transition elements within the building are disconnected from the daylight and the surrounding environment. Also, there is a high level of energy consumption due to usage of air conditioning and artificial lighting. Extensive studies have shown a strong relation between access to daylight and human health and wellbeing. This is an important element in most building design, but especially in hospitals where it can reduce pain, act as an antidepressant and therefore improve the recovery process.

Future generation of hospitals in Albania need to become healthier and more comfortable places to accommodate people and also become more sustainable buildings in order to minimize their carbon footprint. Therefore, the aim of this thesis is to propose a set of guidelines focusing in daylight access and connection to nature which should be followed while restoring existing hospitals or building of new ones.

In order to fulfill the aim, a thorough literature review will be conducted in order to study the importance of daylight as an energy saving factor and most importantly as a factor on human health. In addition, the researcher will select case studies based on best international practices on hospital design. The case studies analysis will be helpful in developing a set of design guidelines which will be used for improving the conditions of the chosen hospital.

Key words: Daylighting, artificial light, energy consumption, sustainable, restoring

ABSTRAKT

TEKNOLOGJITE E REJA PER NDRICIMIN NATYRAL NE ARKITEKTURE DHE PROJEKTIM. ZONA NE STUDIM: SPIALI NENE TEREZA NE TIRANE

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Spitalet publike në Shqipëri janë të trashëguara kryesisht nga periudha komuniste dhe janë te ndertuar njelloj ne blloqe te trasha dhe masive për shkak të nevojave të ndërtimit urgjente në atë periudhë. Pjesa me e madhe e zonave të punës dhe elementet e tranzicionit brenda ndërtesës kane problem te madh me driten natyrale. Gjithashtu, ka një nivel të lartë të konsumit të energjisë për shkak të përdorimit të ajrit të kondicionuar dhe ndriçimit artificial. Studimet të shumta kanë treguar një lidhje të fortë ndermjet drites natyrale dhe shëndetit te njeriut apo mirëqenies. Teknologjite e reja te cilet ndihmojn per nje ndricim natyral me te mire është një element i rëndësishëm në dizenjimin e ndertesave, por sidomos në spitale, ku ndricimi natyral mund të zvogëlojë dhimbje, të veprojë si një antidepresant dhe te përshpejtoj procesin e shërimit. Ne te ardhshmen spitalet në Shqipëri duhet të bëhen ne vende të shëndetshme dhe më të favorshme për të akomoduar njerëzit. Prandaj, qëllimi i kësaj teze është që të propozojë një sërë udhëzimesh duke u fokusuar në qasjen e drites dhe në lidhje me natyrën e cila duhet të ndiqet, ndërsa rivendosjen e spitaleve ekzistuese apo ndërtimin e atyre të reja. Për të përmbushur qëllimin, një shqyrtim i plotë literature do të kryhet në mënyrë të studiuar per rendesin e dritës natyrale si një faktor i rendesishem per kursimin e energjisë dhe më e rëndësishmja si një faktor në shëndetin e njeriut. Përveç kësaj, studiuesi do të zgjedhë raste studimore bazuar në praktikat më të mira ndërkombëtare për dizajn spital. Analiza studimet e rasteve do të jetë e dobishme në zhvillimin e një sërë udhëzimeve të projektimit të cilat do të përdoren për përmirësimin e kushteve të spitalit zgjedhur.

Fjale Kyqe: Drita natyrale, Drita artificiale, Konsumim energjie, Qendrushmeria, Restaurimi

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CHAPTER 1

INTRODUCTION

Daylighting has been an important element in the design and construction of buildings throughout the history of architecture, as for a long time was the only source of light for interior spaces [Bjorngaard and Satterfield, 2010]. So, architects goal was to design large openings to allow the distribution of daylight into building interiors. Since the invention of artificial lighting, designers begun to liberate their buildings from this constraints[Johnsen and Watkins, 2010]. However, nowadays electric lighting in home and office buildings is a significant source of society's energy consumption and lot of researches are focused on new technologies to save energy[Haqparast and Maleki, 2014]. Yet, daylighting is superior to artificial lighting in both quality and illumination level during the day. So, the posed question is: why aren't architects aiming to replace electric lighting during daytime and fully take advantage of natural light? Daylighting and new technologies that allow its usage and measurement, can affect the design of future buildings and can contribute in the demand reduction for lighting and cooling translating into cost saving[Johnsen and Watkins, 2010]. The aim of this thesis is to emphasize the importance of including daylighting in the design from the first steps and the role that it plays in the design process of hospitals.

1.1 Problem Definition

Recently, architects have been facing the problem on how to efficiently design lighting in hospitals spaces without depending on artificial lighting. One of the most difficult issues is to determine the design aspects of the openings that influence the distribution and amount of daylight in the space[Roberts and Marsh, 2001]. This paper is going to explain the main elements that has to be taken in consideration while designing such as building orientation; materials used in the finishing of walls, ceiling and floor; glass used for windows and the size and location of openings. In order to determine all these parameters, the paper will give a short background for simulation programs and explain the importance of including them at the early stage of design.

Furthermore, this research will focus mostly on the lighting design of hospitals, as according to recent studies hospitals are among the biggest source of energy consumption due to the nature of building design and energy demand needed. In most hospitals, working areas and most other staff areas do not have access to daylight [Parliament and Canberra, 2015]. Even fewer working areas have direct access to nature.

As mentioned before, daylighting has great potential for energy savings if the building design recognizes the local climate conditions[Guglielmetti,2010]. Half of the total energy consumption of the U.S.A is used to operate buildings and among all building types, hospitals belong to the most intensive energy user [Johnsen and Watkins, 2010]. More than 40% of the total energy used in hospitals is used for electricity, most of it for lighting[Bjorngaard and Satterfield, 2010]. Hospitals in the future need to implement daylight strategies to reduce energy use, and improve health at the level of individual building occupants, the communities where they are located and globally through reducing carbon driven climate change[Brown and Wyatt, 2010; Brown, 2008]. This is central to their fundamental mission of improving health and well-being. Therefore daylight should be a major design driver for hospital buildings and typologies to both protect the health of building and to support the challenge against climate change [SITECO, 2011].

Therefore, hospital design should aim to reduce greenhouse gas emissions and energy consumption, due to its impact on carbon driven climate change. Natural lighting can illuminate interior spaces of a building through top lighting, side lighting or guided light systems, so daylit hospitals have a great potential for energy savings.

Public hospitals in Albania are typically built as thick rectangular building blocks. Most of existing hospitals are inherited from communism and during the mid-19th century, artificial lighting influenced the design of hospitals by minimizing the importance of the direct connection with sunlight and outside environment. Due to the nature of most working places inside the hospital, deep planned building shapes were more efficient in accommodating the equipment and allow efficient circulation of medical stuff [Islami, 2015]. In result, these thick building form disconnects users in most areas from daylight and access to nature.

1.3 Aim and Research Question

The aim of this thesis is *to determine and discuss methods and advanced technologies that can be used for the design of sustainable hospitals in Albania in terms of daylighting.* The research question is:

How to use advanced daylighting technologies in improving existing hospitals in Albania?

1.4 Objectives

The aim of this research is achieved through 5 objectives.*(table.1)* In order to carry the research efficiently, the outcome of each objective will be used as the main data to address the next objective.

Table. 1 Objectives

Objective 1	• To research the design standards that determine the aspects of sustainble design.
Objective 2	• To investigate new resources and technologies that can maximize the usage of daylight.
Objective 3	• To examine case studies worldwide on how to design lighting in hospitals
Objective 4	• To discuss methods how to use the latest technology in designing hospitals in Albania
Objective 5	• To test all the gained knowledge in retroffiting a pavilion in Nene Tereza Hospital.

1.5 Research framework

The research approaches the inquiry by design approach developed by John Zeisel in 1981, using both qualitative and quantitative data to input theories and inquires to research advanced technologies that can contribute in better design of hospitals in Albania. At first the research will focus to determine the theoretical framework of sustainable design and daylighting, explaining the different classifications and usage of natural lighting. Also, a strong focus will be placed in describing the benefits that daylighting and access to nature can have in human health and wellbeing. Furthermore, for showing the analytical application of designing sustainable hospitals, the research will focus on analyzing successful international case studies.

In addition, the researcher will introduce the chosen case study in Tirana and discuss how the hospital design in Albania has changed along history. In order to better understand the conditions and how users perceive the lighting into the space, the researcher will conduct questionaries' with different users. The study will introduce the importance of simulating programs such as Ecotect in calculating daylighting and together with the outputs from literature review, redesign the chosen pavilion. Finally, the researcher will propose a set of recommendation that can influence the way designers in Albania approach daylighting while designing institutional buildings, especially hospitals.

1.6 The research outline

The dissertation is structured into 5 chapters. The first chapter introduces the research background, aim, research questions and objectives. Once the aim and objectives have been established, the basic outline of the methodology and structure of the dissertation is shown.

Chapter 2, 'Literature Review' critically analyzes the available literature on daylighting and the aspects of sustainable design. Also, this chapter gives a historical background on how architects deal with daylighting as well its definition, importance, benefits on the building form, energy consumption, comfort and health of its occupants. Finally, the research focuses on advanced technologies used to calculate and determine usage of daylighting. Most of these techniques are recently new and can revolutionize the design process in Albania. Also an important part of the chapter, is the analysis of existing international examples that show the benefit of using daylighting at the early stage of design.

Chapter 3 shows the conventional methods used to calculate daylighting and explain the main simulation techniques which enable architects to use simulating programs to determine the amount of daylight needed and size and location of openings. Finally, the research focuses on analyzing the existing conditions of Nene Tereza Hospital. It also gives a general overview on the survey conducted with hospital users, which were really important to determine the main problems the users face every day.

Chapter 4 involves testing and designing the chosen pavilion using one of the simulation program. The pavilion at Nene Tereza hospital is the case study because of the low daylight rates problem in the core spaces where occupants have low or no access to daylighting. The program helps in determine where opening should be placed and minimize the usage of artificial lighting. The results show the importance of using simulating programs while designing hospitals allowing occupants to have access to natural light and view of nature.

Chapter 5, firstly presents a summary of how the aim and objectives have been achieved and then discuss the finding of the research. In the next section, the dissertation will be critically evaluated and establish opportunities for further research.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Daylighting is an important element that needs to be considered more during building design. Many research claim that it allows flexibility in the façade design and can enhance more efficiency in terms of energy and usage of artificial lighting [Li et al, 2002]. Recently, numerous papers and articles have been written about the importance of daylight, by explaining the benefits and how new technologies can maximize the implementation of daylight in the early stages of design. This chapter will focus on the definition of daylight, its benefits and principles that can allow assess to daylight in buildings.

2.2 Definition of Daylight

Natural light, or daylight is considered all direct, diffuse and reflected light from the sun during the day. It includes sunlight [directly from the solar surface], skylight [clear sky cloudy or overcast sky] and sunlight/skylight reflected from other surfaces such as buildings, the ground or other bodies of water [Steffy, 2002]. Daylighting can be defined as the practice of using daylight as the primary source of illumination in a room or building [Ternoey, 1999]. Physically, the light of sun is a source of electromagnetic radiation with a balanced spectrum of colors ranging from ultraviolet 100nm to infrared radiation

10nm[SITECO, 2011]. But only a small part of this light is visible for human eyes, range between 380nm to 780nm[Tregenza and Wilson, 2013]. The characteristics of daylight involves a combination of sunlight and skylight which is constantly changing throughout any given day between sunrise and sunset and over the course of the yearly solar cycle. Daylight changes its color, intensity and direction, depending on the time of the day, season and sky cover [PLEA, 2015]. This naturally occurring relationship between illuminance and color temperature throughout the day helps regulate human circadian rhythm and is experienced as visually pleasant. Artificial light sources are often concentrated in limited areas of the spectrum. Full spectrum light closely matches the spectrum of daylight, however artificially generated full spectrum is limited to a static representation and does not reflect the dynamics in color and intensity of natural light [Estate and Kras, 2011].

2.2.1 Why Daylighting?

Daylight in building design is important as it can maximize visual performance. This is due to its wavelength of the full spectrum and the visible light, which is the reason for daylight's excellent color rendering [SITECO, 2011]. However, if daylighting in buildings is not designed properly and the distribution of light is not controlled, human comfort and visual performance can be negatively impacted due to excessive heat gain, glare and distraction. Also, even though most short wavelength is filtered by glazing, people who are sensitive to ultra-violet radiation can be adversely affected by daylight. Daylighting can also increase energy consumption due to heat gain and increasing internal cooling loads if local climate conditions are not recognized and appropriate screening strategies are applied at the building envelope [Tregenza and Wilson, 2013]. In addition, daylight can influence the occupant comfort, the arrangement of spaces, structure design, energy usage and the type and position of artificial lights. Architects and the whole design team need to understand the implications that daylight has on all the phases of design, construction and most importantly during the use of the building.

2.2.2 Daylighting and View

The current literature on daylighting defines a wide range of benefits and reasons why daylighting should be considered in the building design. View, aesthetics, illumination, health and energy efficiency are some of the main reasons why architects and designers should know how to handle as a design and environmental element. People like to be able to have a view out of buildings they use, such as their homes or work places. To have a view means that the building's occupants are usually connected with the outdoors, through windows or other architectural openings. According to Reluie et al. [1998], views in urbanized areas should be analyzed in three layers: the upper [distant] layer extended from the sky down to the skyline; the middle layer, which includes the fields, hills or buildings; and the lower [close] layer which overlooks the foreground [i.e. plants, paving, and people]. Views which include all three layers are the most satisfying. View offers psychological benefits to users. View also acts as a distant focus for eye muscle relaxation, from time to time during the day [Relmie et aI., 1998].

2.3.2 Daylight and Health

Having access to daylight in buildings through side lighting and top lighting is important for human health and wellbeing. Daylight is the preferred source of lighting, influences humans mood and has a physically simulative impacts in humans circadian rhythm [Boyce, P., 2001]. The dynamic changes of daylight helps to set our inner clock as indicated by several studies about sleep pattern/depression and concentration [Figureuerio, M.G, et al., 2002].

Yet healthcare workers are often disconnected from the outside. This is especially crucial in northern latitudes during the winter season; employees go to work before sunrise and leave work when it is already dark again. If their work environment does not provide connection to the outside, they may not be exposed to daylight for days. This may result in a variety of health problems because daylight has been shown to have numerous impacts on human wellbeing and physiological health. It regulated the body’s circadian rhythm and is necessary to produce vitamin D [Kueller, R.et al, 2006; Kim, J.J. & Wineman, J. 2005], lowers stress [Leather, P. et al., 1998], increases concentration [Heschong, L et al. 2003] and enables performance of visual tasks. Therefore, the accessibility to daylight within buildings, especially in primary work spaces, can help staff to stay healthy and improve performance on critical tasks within their job as health care providers. Additionally, having access to daylight can improve the recovery process for patients [Beauchemin, K.M., 1998].

2.3.3 Daylight and Illumination

Daylight has significant health benefits. Capra [1982] suggests that human health is integrally related to the environment: ' ... our experience of feeling healthy involves the feeling of physical, psychological and spiritual integrity, of a sense of balance among the various components of the organism and between the organism and its environment.' Daylight is one of many important environmental factors. Daylight is involved in the setting of the "'biological clock" and its associated circadian rhythms, and in the production of yeanling D[Bjorngaard and Satterfield, 2010]. Of particular significance to the architect, the lack of daylighting in deep offices can negatively affects occupants of deep-plan artificially lit buildings. Although adequate for visual tasks, artificial illumination is insufficient to trigger the necessary physiological response.

2.3.4 Daylight and Sustainability

Sustainable development is *'the ability of humanity to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs'* [The World Commission on Environment and Development, Brundtland Commission, Steffy, 1987]. According to Steffy (2002), the very essence of sustainability is to attempt to achieve as much as possible with a little as possible, particularly with natural and renewable resources. Daylight offers just such a means. Success of daylighting as a sustainable practice is very sensitive to the integration and interaction of the various building designs, materials and systems (e.g. window dimensions, glazing systems, lighting systen1s, control systems, monitors, etc.). Accordingly, despite the many human and aesthetic benefits that derive from using daylighting for illumination, health and view, it's most evident ecological benefit is to reduce peak energy demand and subsequent environmental impacts.

2.4 Daylighting strategies

While designing, the main principles, hat should be taken in account in order to use daylighting at its best, are:

- **Climate:** All daylighting strategies depend on the specific climate conditions of the building's location. So, it is crucial to analyze the climate characteristics at the beginning. Also, as explained above, before starting the simulation in Ecotect, at first there is the need to put the building location.
- **Urban Planning:** Before designing the building, architects should analyze the footprint and the surrounding buildings. Therefore, the height of the building must meet local regulations that try to avoid over shadow. When regulations does not

exist, architects should be careful to avoid designing a building that doesn't fit in the urban context.

- **Orientation and Shape:** These two elements dictate the access to daylighting. For example, thick building footprints with no perforation, will have a limited availability to daylight due to the small building perimeter. In comparison, perforated narrow building footprints increase the access for daylighting due to longer perimeter walls. Usually, hospitals are built on the north/south orientation which is preferable in terms of thermal control but it may result in significant different room qualities [Garcia-Hansen and Edmonds, 2015]. For instance, facilities positioned in the south façade with be exposed to much sunlight and northern facilities don't have access to direct sunlight, only a reduced amount of diffused light enters the building. However, a west/east orientation is more adequate from occupants preferences, but is more difficult to control the sun penetration into the building[Tregenza and Wilson, 2013].
- **Control:** Daylighting can enter directly or indirectly into building depth through side lighting, top lighting and guided light. The distribution of light should be controlled to avoid glare, heat gain and discomfort indoors [Orrell et al., 2013]. The selected shading elements should address all the challenges each façade faces due to the sun changing positions.
- **Building envelope and opening:** The building skin creates a filter between the interior and the exterior. Openings in it allow the exchange of light and air and provide visual connections to the outside. It also must control sunlight penetration to minimize unwanted heat gain, lighting and glare. Each orientation requires unique skin and apertures design for eastern, southern, northern, and western exposures such as exterior shading systems including vertical or horizontal blinds, sliding shutters and low-emission glazing [Leslie, 2003].

2.5 Shading Strategies

Shading or sunlight control strategies are mechanisms or devices capable of altering the effects of a window. These devices may be:

- Fixed: not operable by the user.
- Moveable: adaptable to different conditions.

Shading devices may also be internal or external devices, or sunlight control integrated within glazing panels. Exterior systems are typically more effective than interior systems for blocking solar heat gain. Exterior devices are attached to either the building skin or an extension of the skin itself to keep out unwanted solar heat. Sunlight control devices may be categorized into 5 different groups as follows: separator surfaces, flexible screens, rigid screens, solar filters and solar obstructers[Aboulnaga, Daylighting Guidelines, 2016].

2.6 Advanced Technologies and Daylighting

During building design daylighting can be considered as an aesthetic element but most importantly an environmental system. The biggest challenge that designers face is the understanding and analysis on how much light is needed in interior spaces and allow an even distribution minimizing glare and heat gain. In relatively hot climates, architects use blinds or glazing with high shading coefficient to minimize discomfort in interior spaces [Aboulnaga, B., 2003]. However, more innovative systems and technologies are needed to maximize the access of daylighting or reduced glare. Recent daylighting systems include passive control of sunlight or actively systems that track the sun path. Types of daylight system should respond to climate characteristics and the position of the building.

The current types include [Garcia-Hansen and Edmonds, 2015]

- Shading systems using diffusive light [blinds, louvers, holographic optical elements, automated blinds]
- Shading Systems Using Direct Sunlight [external light shelves, angular selective skylight]
- Non-Shading Systems Using Diffuse Light
- Non-Shading Systems Using Direct Sunlight

2.6.1 Shading Systems Using Diffuse Light

Designers should select a daylighting system according to building location and climate characteristics. The energy saving depends on the type of system control chosen and the integration of the daylighting system since the early stages of design.

a) Louvers/Blinds

Louvers are a series of exterior or interior slats [also called Venetian blinds] which may be fixed or adjustable. They usually cover the whole opening *[Figure 1]*. Depending on the orientation of the slates, direct solar radiation which falls upon the louvers may be obstructed and / or reflected, or redirected to the interior zone. Horizontal louvers are usually located on southern facades, and vertical louvers on eastern and western facades. Slats can be made of painted or galvanized steel, anodized aluminum, PVC, wood, fabric, etc.*(Figure 2)*

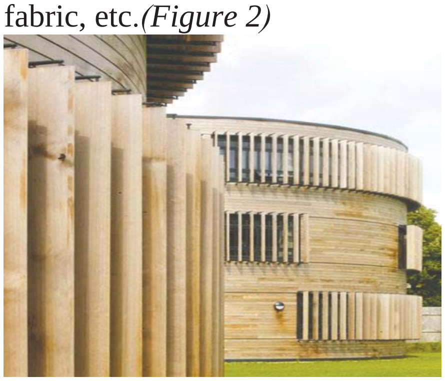


Figure 1. The Langley Academy, [foster + partners et. Al., 2001]

Figure 2. Sidwell Friends School,by KieranTimberlake [foster + partners et. Al., 2001]

b) Automated blinds

Automated blinds are becoming an important element of smart design and intelligent façade buildings. *[Figure 3]* The louvers or blinds have an integrated motor system that allow the automatic movement of the shades. The control of the blinds may vary according to the building typology. It includes infrared remote control, wall switches or electrical relays. [Figure 4],

Figure 3. Centre for Children's Health Research, Brisbane [Littlefair, 2008]

Figure 4. Sunscreen and Blockout Motorised Roller Blinds [Littlefair, 2008]

c) Holographic Optical Elements

Holographic Optical Elements [HOEs] consist of light guided holographic film element that bends the light *[Figure 5]*. They are two-dimensional or three-dimensional [volume holography] recordings of laser light patterns created on high-resolution photographic film, which is then laminated between two panes of glass.

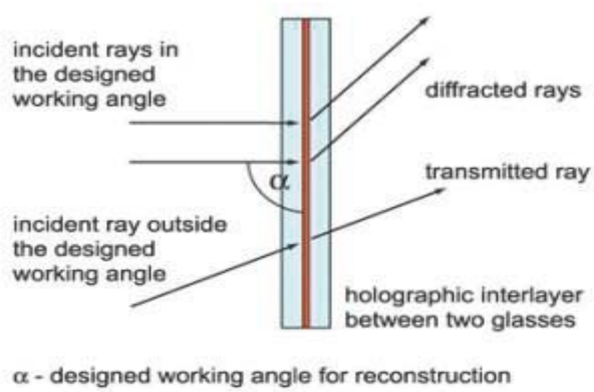


Figure 5. HOE performance to direct light blinds [Littlefair,2008]

The diffraction lattice deflects light only from a predetermined angle of incidence, which means that the holograms can be electronically controlled to track the sun or the changing angle of light across the sky. *[Figure 6]*. In practice, this type of system produces good results for only a narrow range of solar incidence angles [Littlefair, 1996]. In side windows, holographic diffractive films act in the similar way to mirrored louvers, thus there is less solar glare control. Color dispersion can be avoided by applying gratings of some different, special frequency [Littlefair, 1996].

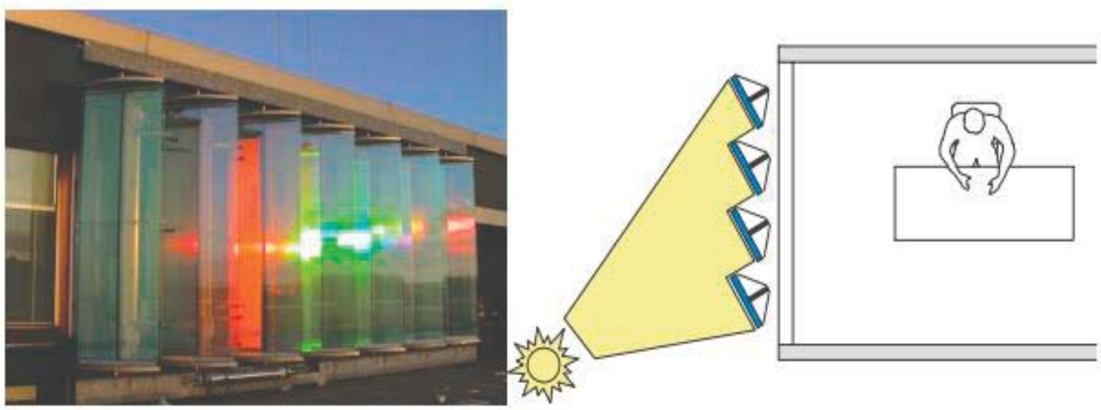


Figure 6. Test facade at University of Dortmund [holographic shading device] [Littlefair, 1996]

2.6.2 Shading system using direct sunlight

a) Angular Skylight

Basic roof openings allows too much high direct sunlight into the room during summer, usually causing overheat and glare[Berkeley and Charles, 2011]. In winter, the sun elevation is low most of the day and basic openings admits very little sunlight into the buildings *[Figure 7]*. Angular selective glazing is designed to improve the performance of skylights or atriums. Angular selective skylight consists of laser cut panels that reduce the direct solar exposure, while allowing significant diffused skylight to enter the interior[Brown and Wyatt, 2010]. The coated glass has anisotropic optical elements that reject or admit light into the building selectively depending on the angle. The laser cut panels are used to constructed triangular or pyramid shape skylights permitting low elevation sunlight to penetrate the building and direct light to be deflected *[Figure 8]*.

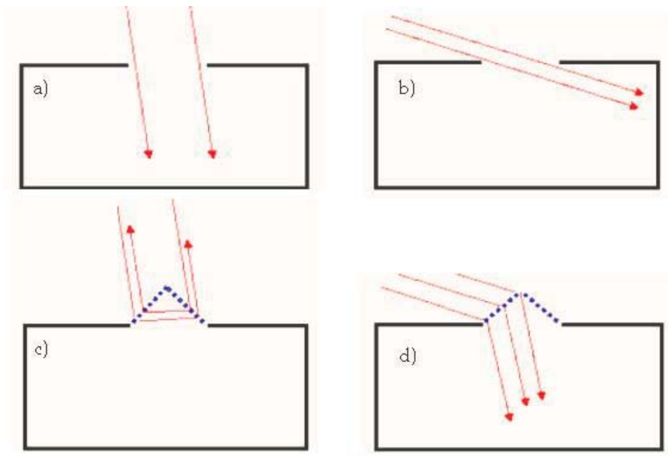


Figure 7. Direct light on normal roof openings vs angular skylight [Brown and Wyatt, 2010]
Figure 8. Angular Skylight [Brown and Wyatt, 2010]

b) Light shelves

A light shelf is an opaque element that allows daylight to penetrate deep into a building. It is usually placed horizontally above eye level in a vertical opening, dividing it into an upper and a lower section *[Figure 9]* [Guglielmetti, Pless and Torcellini, 2010]. Solar radiation falling on the upper surface of the light shelf is redirected to the interior ceiling. It thus provides shade in summer and makes the interior light distribution uniform. Light shelves are made of different materials, the upper surface having a reflective finish such as mirror glass, aluminum or some other highly polished material [Brown, 2008]. Light shelves can be exterior or interior or a mix of both. Exterior light shelf is used to reduce the amount of light entering the building. The interior shelf reflects the light that would have entered anyway into the ceiling and then diffused into the room.

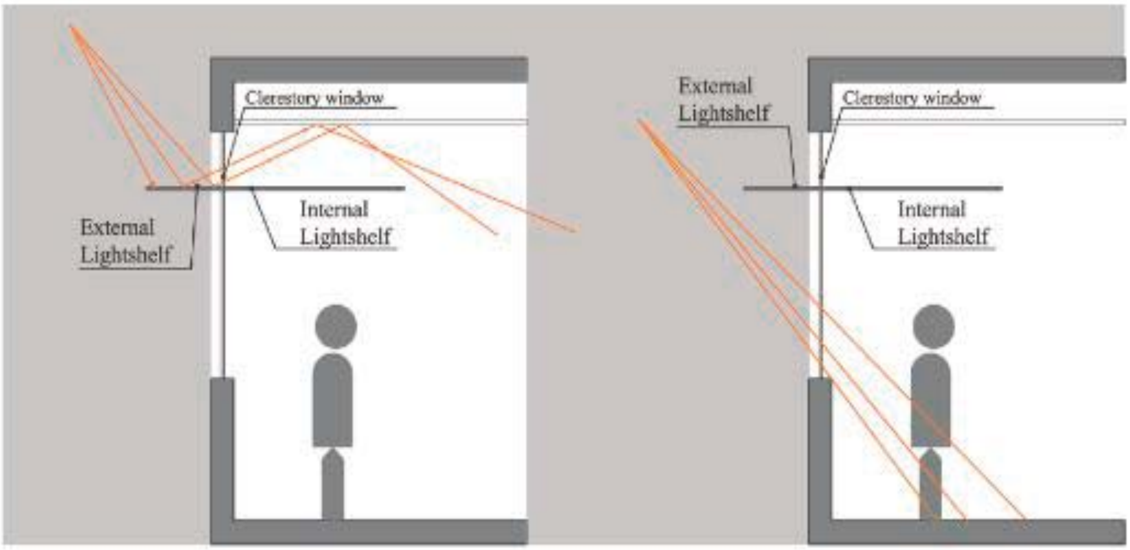


Figure 9. Light shelves

Figure 10. Cambria Office Facility exterior light shelf [Guglielmetti, Pless and Torcellini, 2010]

Figure 11. Exterior and Interior Lighting Shelf [Guglielmetti, Pless and Torcellini, 2010]

2.6.3 Non-Shading systems Using Diffuse Light

a) Anidolic daylighting system (ADS)

Depending on building design and its exposure toward sun, sometimes sunlight penetrating a building exceeds the required illumination causing glare, overheating and discomfort to its users. One of the main challenges that sustainable daylighting design is currently facing is how to provide light to areas situated far from the facades. Anidolic daylighting systems, and specially Anidolic Integrated Ceilings can play and important role in solving the issue[Public works and Government Services Canada, 2002]. ADS are sunlight collector systems integrated into the building façade. They capture the diffused light in the façade and transmit it into the building and at the same time screen out the direct radiation in order to provide thermal and visual comfort inside the building[Note, 2013] *(Figure 12)*. These systems have high performance in both overcast sky and sunny days and make it possible for the entire building to have a constant level of illuminance most of the daytime hours. The anidolic system consist essentially of three subsystems: an external manifold, a solar tunnel and a diffusing element for the interior space[Guglielmetti, Pless and Torcellini, 2010].

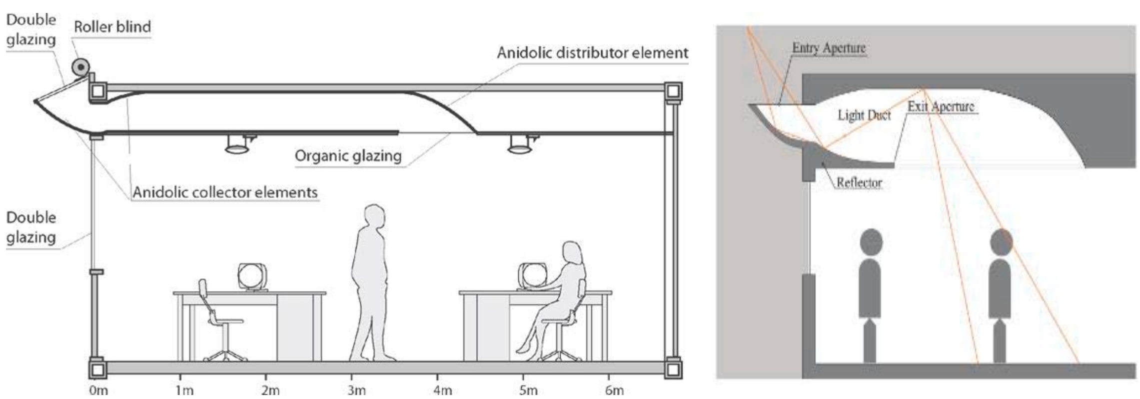


Figure 12. Main component of anidolic integrated ceiling [Note, 2013]

The concentrator is positioned on the roof, to receive the diffused light from the celestial vault, where it captures diffused sunlight, regardless of the sky conditions. The Anidolic Integrated Ceiling optical sensors make use of the parabolic concentrators that collect the diffused daylight coming from the sky and then direct it towards a specular light duct above the ceiling, which transmits the light captured to the end of the room [Brown, 2008]. So, anidolic systems, are applicable mostly to non-residential buildings and in cases where windows alone are not sufficient to ensure adequate levels of illumination.

The LESO solar experimental building is a research facility that studies and test in situ several advanced solar technologies. In 1999, they refurbished the southern façade by using anidolic daylight systems in order to design a sustainable façade. *(Figure 13)*, shows the main components of the façade and how the system works. All the external solar blinds are monitored and the users have access to move them at their needs for visual and thermal comfort.

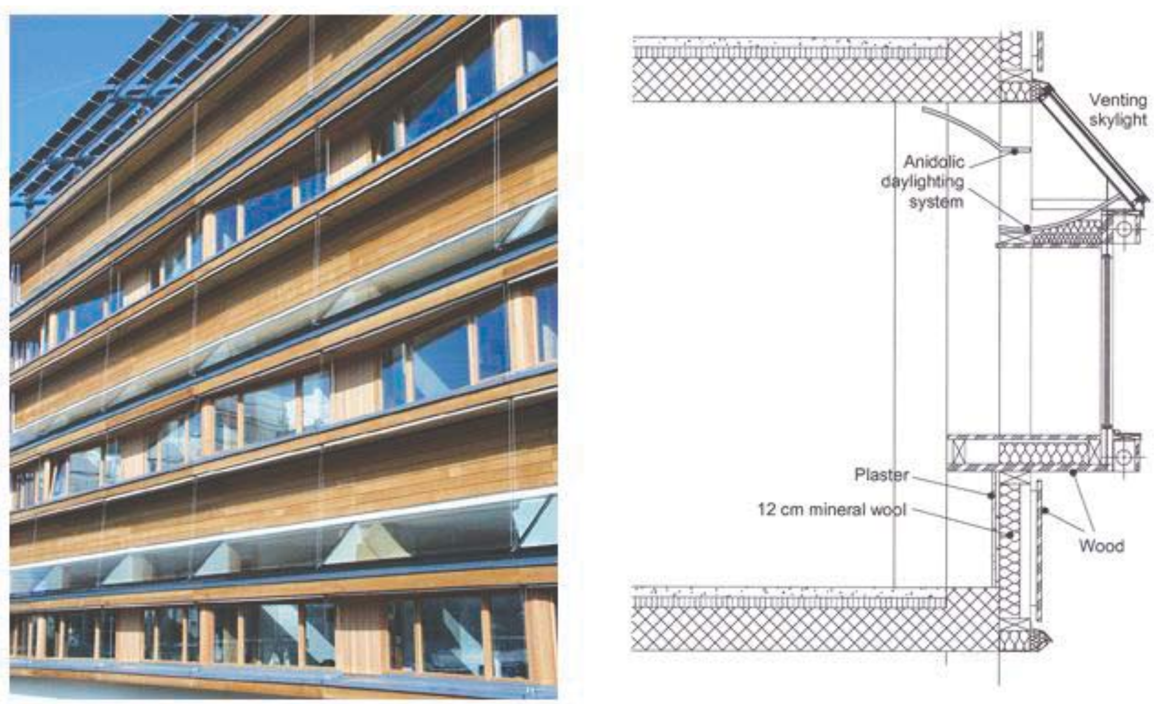


Figure. 13. LESO solar experimental building south façade [Brown, 2008]

b) Zenithal Light-guiding Glass

Zenithal light-guiding glass systems allow the intensification of illuminating the whole depth of the room by redirecting diffusive light. The main element consist of a holographic polymeric film that is positioned between two glass panels. The redirection of the diffusive light coming from the zenithal region of the sky is achieved by the HEOs element. This element should only be used in facades that don't have direct sunlight as in that case the system may face color dispersion. Also, zenithal light-guiding glass should only be used on the upper part of the windows at a 45 angle because it causes small view distortion.*(Figure 14)*

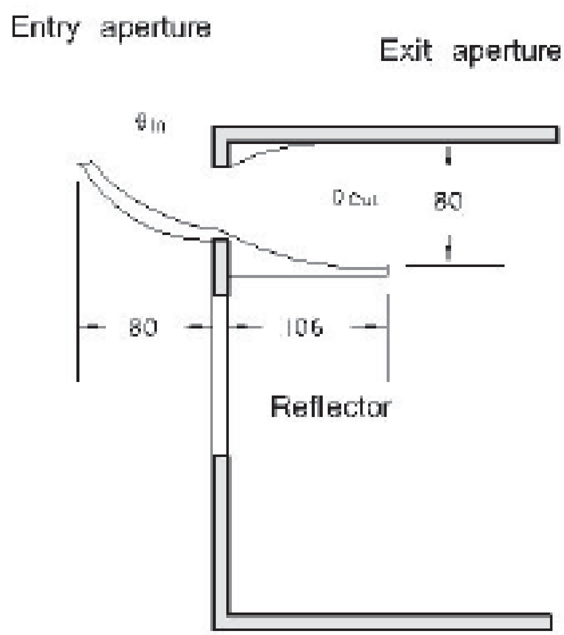


Figure 14. Zenithal light-guiding glass [Brown, 2008]

2.6.4 Non-Shading Systems Using Direct Sunlight

a) Sun-directing glass

Sun-directing glass is an evolved glazing system made by sealed concave acrylic elements vertically arranged on top of one another. This type of glazing allows direct incident light to be directed and angled towards the ceiling, in a pre-established direction. To prevent the device totally excluding the view of the outside, sun directing glass is normally fitted at the top of a window, so as not to preclude the view or alter the color, while the lower portion of the window is made from double standard glass and possibly shaded using traditional systems [Australian et al., 2015]. Sun-directing glass offers considerable flexibility in application: it can be inserted above the height of an unobstructed view, either inside or outside a window, on an existing window or even onto transparent facades, where retrofit operations are necessary[Public works and Government Services Canada, 2002] *(Figure 15)*. They can also be effective for horizontal apertures in the case of top lighting, in the presence of skylights and glazed atria, as long as the system is tilted to a minimum angle of 20 to encourage solar penetration, but avoid irritating glare and direct the solar rays deflected downwards[Johnsen and Watkins, 2010]. The best orientation for this type of glass is south façade and in east-west orientations its maximum effectiveness is obtained in the early hours of the morning and afternoon.

Figure 15. Sun-directing glass in the upper part of the façade. [Public works and Government Services Canada, 2002]

c) Prismatic Panels

The principle underlying prismatic glazing is the alteration of incoming daylight by means of refraction and reflection. Typically, prismatic glazing comprises glass sheets that are flat on one side and faceted on the other, in the form of long parallel prisms[SITECO an Osram Business, 2011]. The prismatic sheet controls light and heat by reflecting the energy, instead of absorbing it. Prismatic systems can be utilized to redirect diffuse light from near the sky zenith towards the back of the room, which would otherwise receive no direct skylight[Roshan, 2013]. There are two primary types of prismatic glazing: sunlight directing prisms, and sunlight excluding prisms *(Figure 16)*

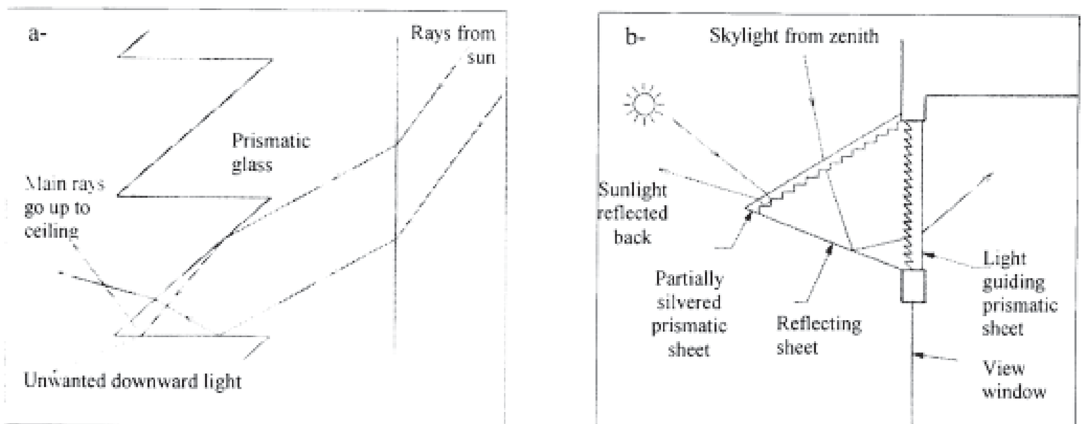


Figure 16. Schematic prismatic panels performance [Ruck, 1989]

Sunlight directing prisms work on the same principles as the mirror systems. Figure 15 shows typical ray paths through a schematic prismatic sheet. Usually, the prismatic panel is installed inside a double glazed unit, and located in a clerestory type system since refraction distorts and obscures view to the outside. According to Ruck (1989), this arrangement offers transmission efficiency between 50 to 70%, depending on the solar altitude. For energy efficiency and occupants' comfort, the glazing needs to be adjusted seasonally to optimize deep daylighting onto the ceiling surface by controlling the direction of reflection. Sunlight excluding prisms feature in a system whereby the aim is to reject direct sunlight while adn1itting skylight from near the zenith[Roshan, 2013]. The tilted prismatic sheet has one face of each prisn1 silvered, so that light from the areas of sky where the sun could be will be reflected back outside. Diffuse light from higher altitudes is admitted and refracted onto the ceiling by the inner, vertically fixed prismatic sheet. This system allows glare-free lighting into the depth of the room, and is particularly useful where Visual Display Units are used[Tregenza and Wilson, 2013].

d) Laser cut Panels

Laser cut panels perform the task of re-directing incident light. They are also counted among the shading systems, by virtue of their inherent ability to manage particular incident angles of light, within whose range the optical properties of the panels allow reflection of the full quota of light, thus protecting interiors from glare and overheating[SITECO, 2011]. These are thin panels cut by laser to create prismatic surfaces of infinitesimal size in a transparent acrylic material, PMMA- Polymethyl methacrylate, capable of directing natural light. When incident light is inclined at an angle of about 30 all the rays are reflected towards the outside, while inclinations equal to or less than 20

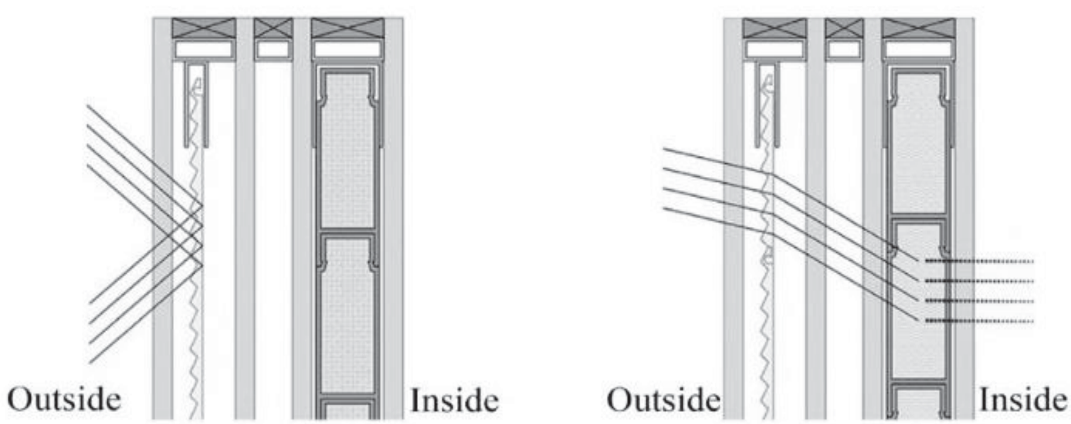


Figure 17. Laser cut panels performance [SITECO, 2011]

from the horizontal, light is directed towards the surfaces of the ceiling and diffused towards the bottom of the interior space, far from the apertures[Public works and Government Services Canada, 2002]. Thanks to its conFigureuration, laser cut panel possess a variable dynamic behavior that guarantees maximum protection from incident rays during summer, and a greater level of illumination than plain transparent glass during winter *(Figure 18).* The main advantage of these devices is the reflector system that can be used either vertically or horizontally. They also have the ability to consistently reduce glare in the vicinity of the transparent surface, by virtue of the fact that the diverted ray is directed upwards, while the radiation not diverted continues its journey downwards, together with the incident light[Meerbeek, van Loenen, te Kulve and Aarts, 2012].

Figure 18. Laser cut panel office building, London [Public works and Government Services Canada, 2002]

2.7 International Case Studies

It is critical to investigate best examples of hospital and daylight design outside Albania for current guidance. Different building typologies illustrate that a hospital can provide daylight and views to the outside in almost all parts of the building and still provide successful, safe and efficient health care. Each chosen case study will be introduced to understand why they were chosen and then analyzed in terms of daylighting systems, comfort, energy efficiency and also aesthetics.

2.7.1 Akershus Hospital Norway

The Akershus University Hospital in Norway was chosen as a case study due to its successful integration of narrow building footprint for the inpatient units and its integration of courtyards for the diagnostic and treatment department. The hospital was awarded the Best International Design for Healthcare Buildings. It was designed by Arkitejtfirmaet C.F Moller and completed in 2008. Architects main concept was to provide a good connection between the patients' rooms and the outside environment. In order to provide natural ventilation and access to daylighting, the main street is built as atria with side top openings. The whole complex form of the hospital, offers a variety of interior spaces, allowing all users to feel at home. In addition, the five storeys internal atria offers a variety of community services and facilities, creating a sense of community and proving that hospitals can also be less stressful urban environments. The whole boulevard is covered by a glass roof which allows the penetration of natural light into the building depth.

Figure 19. Akershus University Hospital: a) internal boulevard; b) patient room; c) shading elements in wooden façade [Arkitejtfirmaet C.F Moller, 2008]

2.7.2 Causality hospital Austria

The second case study is the six storey Casuality hospital in Linz, Austria. In the south-west façade the windows opening reach the complete room height resulting in visual and thermal discomfort for tis users. Due to the many problematics caused by over exposure to daylighting, the commissioned architect decided the installation of moveable prismatic solar protection.


Application areas for moveable prism system

Facade	Roof	New building	Old building/ refurbishment	Solar protection	Glare elimination
++	+	++	o	++	o

++ highly suitable + suitable o conditionally suitable – not suitable

Figure 20. Movable Prismatic Building Façade [Nickl&Partner, 2010]

The movable blinds are placed in the upper part of the balconies. The superimposed lamellae protects the whole glaze façade from summer sun. In winter, the prismatic lamellae allows the penetration of low sun into depth of the rooms. Furthermore, the prismatic plates have the ability to rotate horizontally in order to guide the reflection of daylighting into the patient rooms during cloudy days. *(Figure 20)*

Figure 21. Prizmatic panel detail [Nickl&Partner, 2010]

2.7.3 Pediatric and Cardiac Centre, Austria

This hospital, designed by Nickl&Partner was chosen to illustrate the approach of integrating courtyards in the support zone of an inpatient race-track plan. The main concept was to perfectly fit in the surrounding urban environment where most of rooms and offices have maximum access to daylighting and nature. The folded panels offer a pleasant and playful façade design. But also it serves as an insulator and acts as a barrier from the street noise pollution. The integrated courtyards and the diverse location of the multi-layered façade panels, allow users and visitors to experience all the different climatic changes during the day. The main facilities of the hospital are connected by a two-storey high walkway which along the way offers diverse service and playing facilities.

Figure 22. Pediatric and Cardiac Centre multi-layered facade panels [Nickl&Partner, 2010]

Figure 23. Natural daylighting access into the interior spaces of the hospital [Nickl&Partner, 2010]

2.8 The impact of shaded devices

Many studies have demonstrated that the proper use of daylighting has a great impact on energy load. To achieve good daylighting, a number of building design variables must be studied. This chapter has reviewed some daylighting principles, and concluded that any study of daylighting performance in building should be made in accordance with three scales: the micro, meso and macro scales. In addition, this chapter sets out a study of the impact of shading systems on thermal, comfort and energy performance. Advances in the various technologies of glazing are reviewed. This review begins by looking at the properties of shading systems, passing through kinds of glazing systems, ending with a description of glazing with integrated shading devices. These solutions tend to become increasingly responsive to the environment as additional layers are added, and greater variability and changeability are included in the systems. It is apparent that there are a large number of available glazing systems: each with its own advantages and disadvantages.

CHAPTER 3

DAYLIGHTING CALCULATION

This chapter provides a general literature review on daylighting calculation and explains the reasons of choosing Ecotect for analysing the chosen case study. The aim is to understand how building use one or more of the different daylighting systems and how all systems needed to provide visual and thermal comfort such as ventilation, and energy efficiency systems.

3.1 Daylighting assessment

Daylighting design is both an art and a science. Qualitative information and visual feedback on a given daylighting concept are usually as important as the quantitative Figures that reflect the engineering aspects of daylighting design. Lighting recommendations reviewed in Chapter 2 showed that good natural lighting, and unobstructed views out of a building are minimum standards required by the guidelines for workplaces in many countries. Some of these conditions can be broken down into criteria quantizing the perfom1ance of a design solution with a particular design system, such as daylight factor, glare index, illumination, etc. These factors are numerical performance criteria derived from specific formulas. Quantitative recommendations are often made to predict and analyze qualitative aspirations, such as safety, good visibility, visual comfort and thermal comfort [Osterhaus, 1993]. *Table 2* shows the recommended levels of minimum daylight factor in different environments and building types.

In all daylighting design measures, attention should not focus only on adequate levels of lighting in a room. Attention should also be given to enhancing the quality of lighting, ensuring an even and intense standard of illumination in all areas. Although investigations focus on trends in quantitative recommendations, it is necessary to evaluate those trends in the context of qualitative needs and assumptions. [view out, wellbeing, visual comfort and mood, etc.]

Table 2. A levels of general or minimum daylight factor in different environments [Osterhaus, 1993]

Building Type	Recommended daylight factor %	Qualifications/Recommendatios
Dwellings		
Kitchen	2	Over at least 50% of floor area (minimum of 4. 5sq.m)
Living room	1	Over at least 50% of floor area (minimum of 7.0 sq.m)
Bed room	0.5	Over at least 50% of floor area (minimum of 5.5sq.m)
Schools	2	Over all teaching areas.
Hospitals	1	Over all ward area.
Offices	6	On drawing boards
General	1	With lighting penetration of 3.75m
Typing and computing	4	Over whole working area
Laboratories	6	General recommandation
Factories	5	Maximum on wall or screen
Art galleries	6	General over all area
Churches	1	Depending up on function, the recommendation may exceed 1% is generally desirable in most public building
Public buildings	1	

In accordance with the review of theories, the best use of daylighting is assessed along with the following associated qualitative and quantitative performance expectations:

• Architectural: the impact of facade conFigureuration and plan morphology in collecting or rejecting the daylight needed to illuminate indoor spaces and enhance the environmental conditions of the workplace.

• Lighting energy savings: the replacement of indoor electric illumination needs by daylight, resulting in reduced annual energy consumption for lighting.

3.2 Daylighting Simulation Programs

In the last decade, there has been a growing concern about the development tools used to provide assistance in daylighting design. Several surveys have been carried out during the last 10 years to identify the tools available to monitor the behaviour of daylighting in buildings [Baker et aI., 1993; McNicholl et al., 1994; Kenney et al., 1995; Aizelwood and et al.. 1996; Baker et aI., 2002].

Although old tools such as empirical equations, tables and diagrams, based on practical experience or simple calculation, may reflect historical conditions now that computer technology is available. Nevertheless they could be useful in the design of a simple evaluation tool. However, in the past 50 years a extensive number of computer programs have been developed allowing the assessment and calculation of daylighting. A computer simulation tool is needed to predict and calculate the daylighting factor, electric lighting consumption, and the potential savings due to electric lighting control strategies. Daylighting simulation programs are becoming important because they allow to calculate daylighting factor for any building shape. Each program available produces an accurate calculation, because while entering the location of the building it gathers all the information for the conditions of the sky. According to the Canadian Supreme institution,the most three recommended programs for daylighting simulations are Ecotect, Radiance and Velux.

3.2.1 Ecotect

Ecotect andVelux are very innovative and simple 3D simulation programs featuring an extensive simulations functions and building performance analysis. The main features that sets the softwares apart from other similar programs is the ability to support designers at the early stages of design as well as validation and analyzation of final design or existing buildings. It allows users to analyze several parameters, such as: daylight levels, artificial lighting, sun penetration, over shading, shading device design, thermal comfort temperature, acoustic reflections, environmental impacts of the project and its cost [R.Andrew; M,Andrew, 2010] . It is mostly dedicated to architects in order to contribute in designing sustainable, energy efficient and comfortable interior spaces while designing and building type.

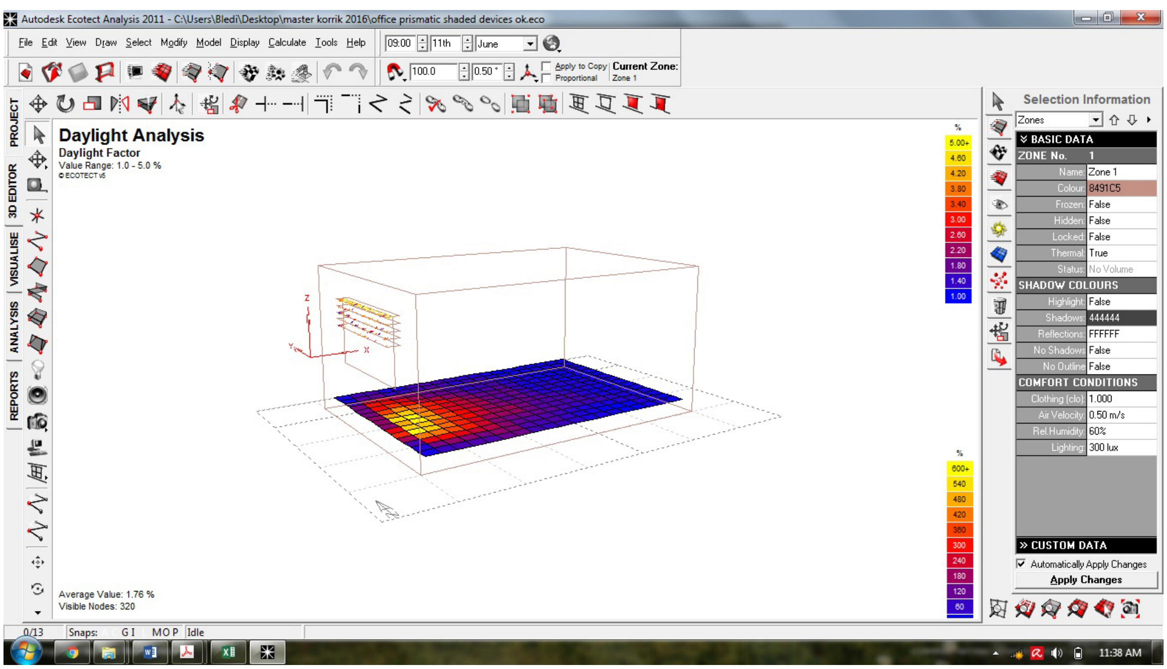


Figure 24. Ecotect Overview

Designers are able to analyze any building form and select a variety of materials and building elements and quickly compare the results of the natural lighting levels into interior spaces, hourly temperatures and monthly heat loads changes and reflect on which element is better to use to design a sustainable building. In order for Ecotect and Velux to perform all the different analysis abovementioned, the software requires a lot of data for the specific building. At first, designers can build the building model and after it is refined the user can begin to enter more specific details to produce a more accurate model. This feature allows users to analyze natural light, sun exposure and shading elements at the beginning and begin to shape the design according to the results.

3.3.1 Albanian Hospitals

The current healthcare system in Albania is facing a lot of issues in terms of services offered to the users and the interior space conditions. About 80% of the current hospitals are inherited from the communist regime with some changes in the façade of a few buildings.

The first hospital was built in 1949 in Gjirokastra and the last on in 1989 in Peshkopia. Among the leading designers during the period between 1945 to 1990, are: Skender Luarasi, Exile Cano, Fred Sallavaci, Faik Alimehmeti, Agim Mufti, Adem Stërmasi etc. The architecture of the hospitals were conform the socialist realism ideology, But during the 60s, hospital architecture started to slip slightly from the directives of socialist realism, creating an unique character, an architecture that started to become national, featuring characteristics from local elements and was basically functional. A recent study of hospitals in Albania, emphasized the architecture values of these buildings. The main common characteristics of the white buildings are: long corridors, rooms from both sides, white and gray painted wall, high doors, ceilings, windows and stairs [Islami, 2015].

ArchitectS of the era, were at first concerned about the internal technology operation of the building. Then, they draw attention at designing interior environments that provide well-being and are psychologically attractive to the human eye. Furthermore, a few projects are aesthetically pleasant and very interesting for the period such as the Peshkopia Hospital, Permet Hospital and the Neuropsychiatry Hospital in Shkodra. Psychiatric rehabilitation pavilions are the types of buildings, within the hospital, that require special care. In order to facilitate the rehabilitation of patients quickly and without creating a tense situation, they had different architecture; not the classic image of the hospital, with a long corridor of rooms from both sides. Both in Shkodra and Tirana psychiatric hospitals, we don't encounter classic corridors. The interior spaces have angles, regular or irregular pattern repetition that bring creativity [Islami, 2015].

However, the current situation of hospitals does not respond to the required need for comfort and well-being of its users. Most of rooms are subject to glare, overheating, poor natural ventilation, and poor quality of outer open spaces, low energy efficiency and high reliability on artificial lighting. A wide range of hospitals are at the critical stage and there is need for full restoration of the façade and interior spaces. An example is the hospital of Berat, where patients have to struggle with poor room conditions, lack of natural ventilation, glare in the south façade but the rest of the building [where are positioned most of the patients rooms] doesn't have access to natural lighting. Another big issue is heating. There is an urgent need to find alternative solutions to provide constant heating with low cost [advanced shading technologies can be a solution].

3.3.2 University Hospital Centre “Mother Tereza”

University Hospital Centre "Mother Teresa" in Tirana is the largest medical institution in Albania and the only academic health institution of its kind in the country. Currently, this institution provides ambulatory health services for about 150,000 people a year, hospital care for over 60,000 people a year and emergency service for about 200,000 people a year.

The hospital is located in the north-east of Tirana and occupies an area of 165,000 m2. In relation to important links and the surrounded area, it is confided by Bardhyl road in the west, Dibra road in the north, the Monastery Congress in the south, the Eqerem Cabej School in the east and residential buildings. The campus is composed by 9 hospital facilities, with a capacity of 1,612 beds and offers medical assistance to 400 patients at a daily basis. Hence, the hospital for Internal Disease’s was chosen for the purpose of this research. The building is located near the main entrance of the campus and is one of the largest facilities part of Mother Tereza Hospital.

It is a 6 storey building and most of the patient rooms are positioned in the north and west façade. In the south and east façades are allocated the offices and other types of rooms and few patient rooms. The researcher had the opportunity to enter the patient’s rooms but was not allowed to take picture due to the sensitivity of the environment. However, he had

Figure 25. Nene Tereza Hospital Campus [yellow- chosen building]

the chance to analyze the room conditions in terms of lighting quality and ask few questions to its users.

Figure 26. West Facade of Internal Diseases Hospital

Figure 27. East Facade of Internal Diseases Hospital

3.3.3 Method of Study

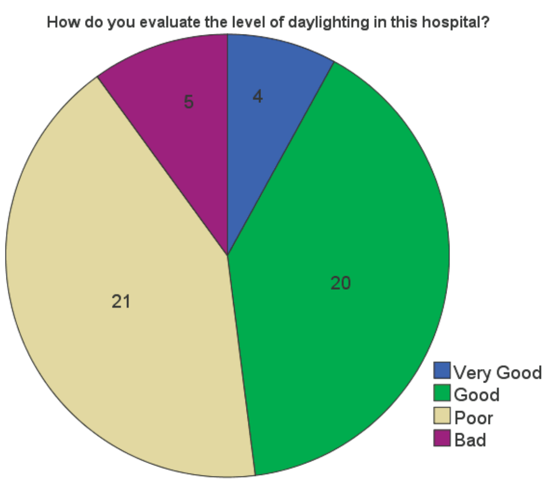
In order to properly study the conditions of the hospital in terms of lighting and specially daylighting, the researcher conducted questionnaires with staff, patients and their family members. Most of the questionnaires were distributed to adults in the waiting area. The total number of questionnaires filled by hospital users is 50, from which 12 were patients, 25 family members and 13 were staff members. As the people working in the hospital, use it every day and know its problematics better, some of the staff members were asked to give further comments and details. The observation started in November 2015, that marks also the first time the researcher had on the site. After analyzing the whole campus and photographic survey of the chosen building, it was decided to conduct the questionnaires in different days in order to gather data from a variety of users. The questionnaires were conducted on the 10th, 16th and 17th of January, all weekends were the number of visitors resulted to be higher and enabled a quick process.

3.3.3.1 Rationale for the questions

All the questions are linked to the theoretical understanding developed through literature review and the responses are then used to better analyze the lighting condition in the chosen case study and the problematics that the users feel the need for urgent improvement. Due to the nature of the hospital environment, the researcher tried to keep the questions simple, straight to the point and easy to fill within 5 minutes. Most of the time, the researcher asked the questions and then filled the form, because most people were in a hurry or unable to fully assist the process such as patients and worried family members. The whole questionnaire in Albanian and English is shown in Appendix 1.

3.3.3.2 Questionnaires Analysis

The pie charts below illustrate the analysis for some of the data gathered from the survey conducted inside and outside the environment of the chosen hospital.*(Figure29)*, illustrates users opinions on the quality of lighting and especially natural lighting in the main interior spaces of the hospital. Most of the participants, around 42%, were disappointed from the current state and argued that it is time for more investments to improve the conditions in the hospital. They complained for the poor lighting conditions, glare and overheating in the west façade, or lack of access to daylighting in the north and east façade. Others stated that access to daylighting is satisfactory, but there is the need for some additional improvements such as more effective ways to deal with glare mostly in office buildings. Only 4 people didn't have complaints about the current state, and is interesting that all of them were staff members (for more information check Appendix 2-5).



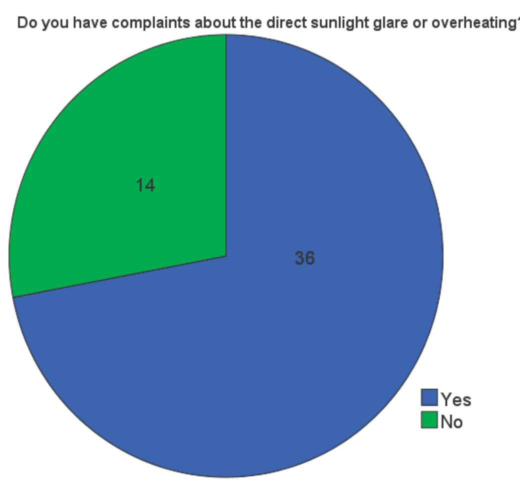
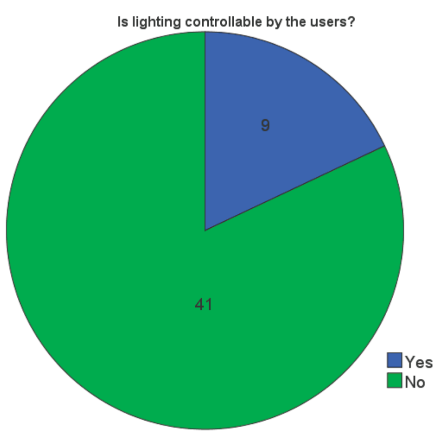


Figure 28. Effect of direct sunlight into the building
Figure 29. Level of Daylighting pie chart

While asked if they had complaints about direct natural light in the interior, 72% of the participants claimed to have issues with the current state of direct light *(Figure 31)*. Although the hospital has also the problem with lack of access to natural lighting in some patients' rooms, the Figures for this questions are relatively high due to the fact that most participants (visitors or family members) were allowed only to stay in transition areas such as corridors that were subject to overheating. Also, around 8 staff members complained about glare issues in their office building and 11 of them had troubles in reading or performing the work properly in their computers.

Regarding the ability to control the quantity of light entering the room, the diagram in Figure 29 shows that 21 users strongly agree that they cannot control the lighting. This is due to the fact that most rooms have lack of shading devices or direct access to control the artificial lighting. Also, around 69% of the staff members claimed that the current blinds were not effective solutions because either u have to suffer glare or depend 100% on artificial lighting even during the day. This was also a big issue in terms of access to pleasant nature view, because the presence of blinds affected this access wherever it was possible.



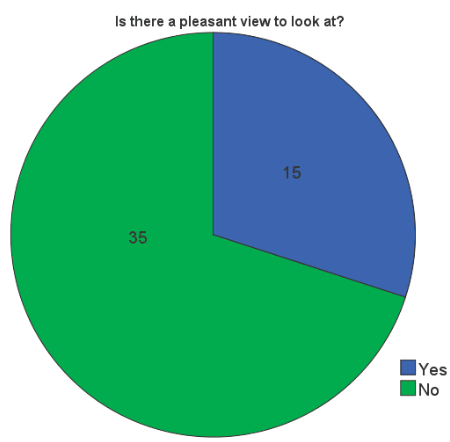
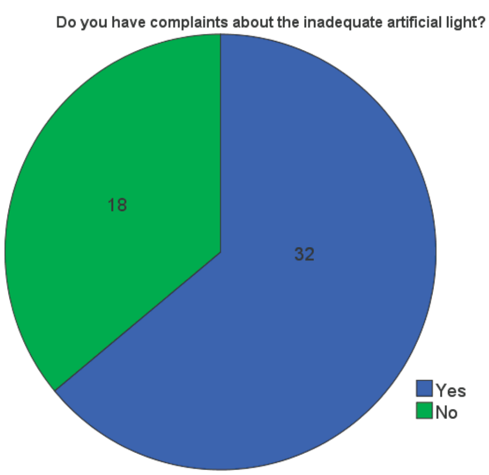


Figure 30. Pie chart of lighting control

Figure 31. Opinions about view from the window

As researched from the literature review, not only daylighting can have a good effect on the well-being and recovery of its users, but also access to nature. While asked if they had a pleasant view from their window, 70% of the participants strongly denied having access to nature *[Figure 31]*. Around 8 patients claimed that spending a long time in the current rooms was depressing and sometimes overwhelming. They are not allowed to leave the hospital environment and have to settle with current conditions. Also, their family members were strongly disappointed from this fact, as they need to spend many hours inside corridors and no proper green spaces where patients can go out.

The findings show that 64% of the participants agree that the artificial lighting is inadequate*(Figure 33)*. According to the observations of 19 family members (also confirmed by the researcher), the artificial lighting is used also during the day when there is no need for them to be on. The paradox was that artificial lighting was on in transitions areas that were subject to glare and they were absent in patients which had big issues with access to light. Even though 37 participants said they didn't know if the bill of the hospital was relatively high, 9 of them claimed it was high and this was also due to the poor control and regulation of artificial lighting.



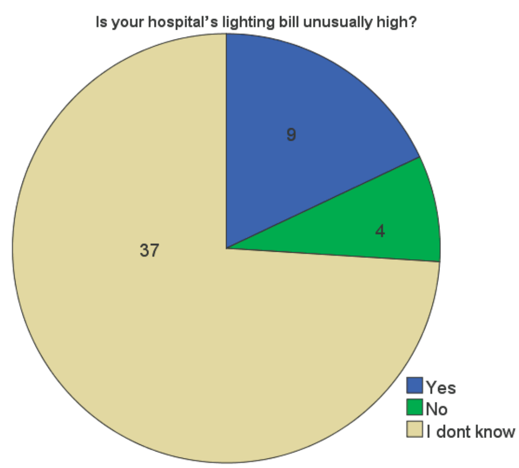


Figure 32. Complaints about the artificial light

Figure 33. Hospital lighting bill

The overall image of the daylighting conditions in the hospital, is a result of the all infrastructure and lack of investments from local authorities. The quality of most of the room spaces is poor and users have to suffer as these spaces are subject to constant poor lighting conditions and it affects the well-being of staff but most importantly to its patients who need specific conditions to recovery fast. It is clear however, that despite some attempts with the usage of blinds, it is time for more advanced elements that can reduce glare, offer comfortable interior areas in terms of lighting and heating and most importantly contribute to a more sustainable hospital. Among all problems stated by the participants, the researcher found out that the new shading elements proposed should also allow access to pleasant view.

The aim of this chapter was to give an overall view on the different methods of calculating lighting. Although there are a lots of tools, according to the literature reviewed the most effective and quick tool the analyze daylighting in existing buildings, is Ecotect. It is a helpful simulation software that allow designers to analyze all the aspects of daylighting. Also, the chapter examined the condition of existing hospitals in Albania, with a stronger focus on the choose case study. The questionnaire conducted were very useful in understanding user's perception of space and lighting conditions. All the data gathered will be used in redesigning the chosen interior space.

CHAPTER 4

APPLICATION AND RESULTS

In recent years, the relevance of including advanced technologies that can allow the design of sustainable and energy efficient building has gained also the attention of architects in Albania. A variety of buildings, mostly in the capital, have been or are under restoration in order to design more efficient and comfortable interior spaces and also respond to the need of reducing the emissions of greenhouse gases. Furthermore, a few hospitals have started or planned to renovate at least their façade which can be a big contributor in reducing the energy consumptions and cut down the electric bills.

4.1 The application

4.1.1 Ecotect

The area which will be studied is a patient room and all floor plan located in the Internal Diseases Hospital building in Tirana. This room is located in the third floor and has several problems such as lack of access to sunlight most of the day [summer or winter] which forces its users to rely most of the time of artificial lighting. Most of the problems in this floor are due to the unequal natural light distribution and room allocations. The daylighting is unable to reach in depth inside the whole building. Also, as showed from the questionnaire analysis, in the west façade that is subject to glare are allocated the office buildings. The Ecotect analysis should help to answer two questions:

- *How to improve the access to daylighting and increase its level in patient's rooms?*
- *How to reduce glare and heat load in the west façade?*

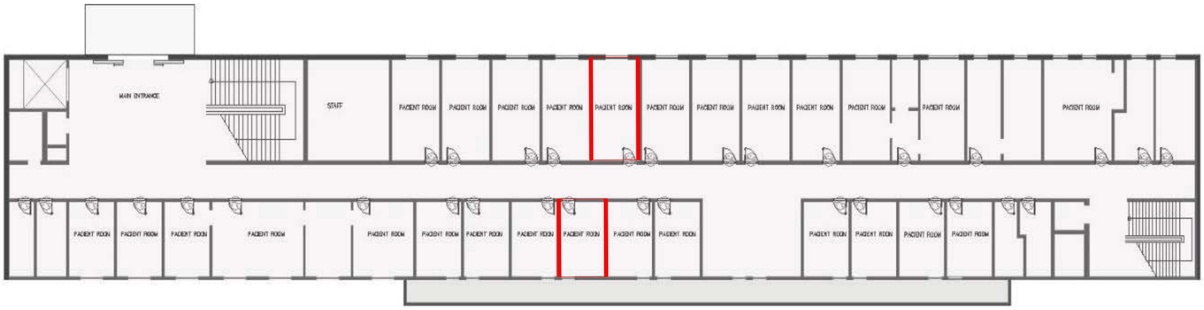


Figure34. Typical floor plan

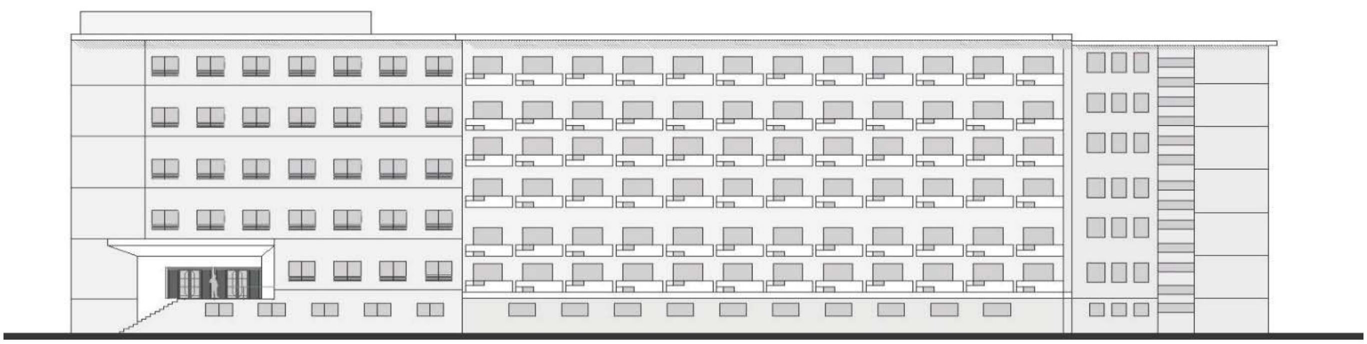


Figure 35. West Facade

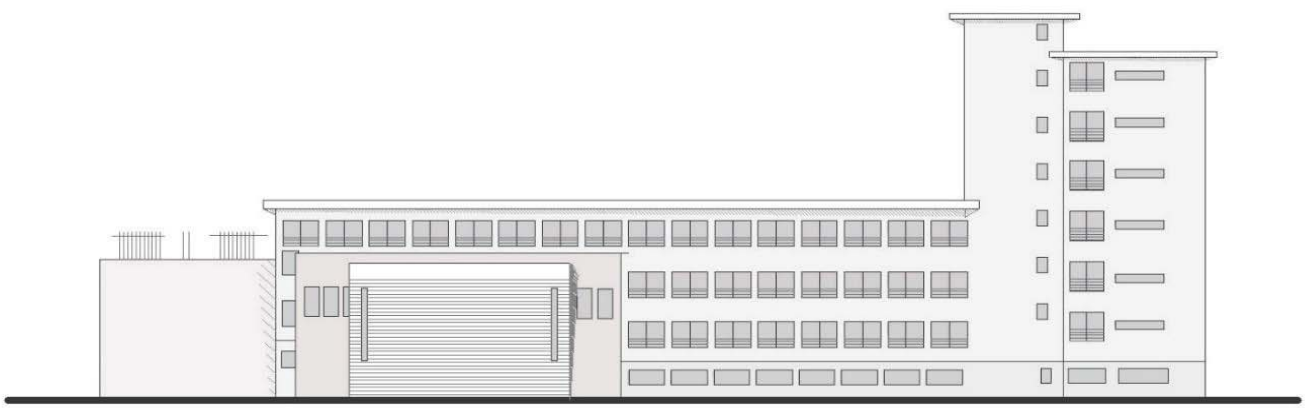
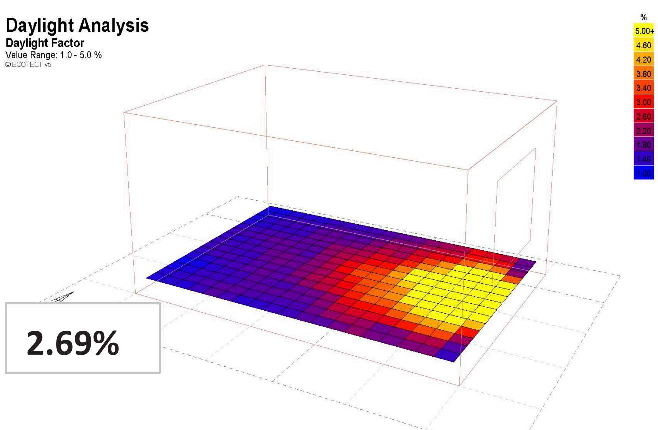


Figure 36. East Facade

As shown in tabale 1 in chapter 3, for bed rooms the daylighting factor should be around 1.5% and 6% for offices which have drawing tables or computers. The drawn percentage is important in achieving the desired visual and well-being comfort. Ecotect and Velux will be a useful tool to define the critical points in terms of high or low lighting levels and also define which the best technique to treat these problems is. The drawing entered in the software, will be analyzed in different seasons, because the lighting rate, sun paths and light direction into the interior spaces changes during the day. So, all these data will be useful to determine the critical times and location of daylight into the building spaces. After entering the specific location of the hospital, Ecotect and Velux will perform accurate sun path simulation and other climatic conditions that can affect the natural lighting access in interior spaces. The model entered in the software should be simple, and just reflect the accurate dimensions, openings size and building contours. The contours plan is useful to identify the weakness points of the room and define the best way to improve these conditions.

Patient room simulation:



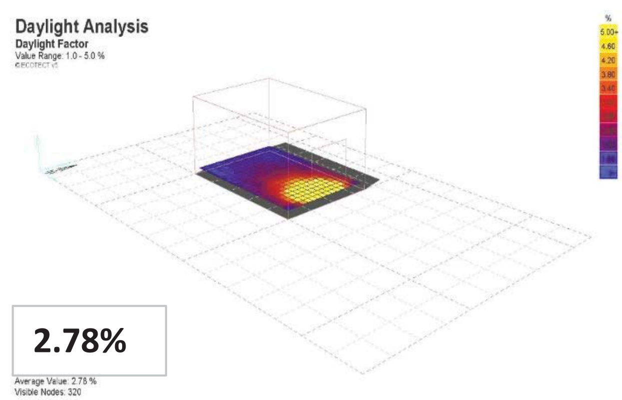
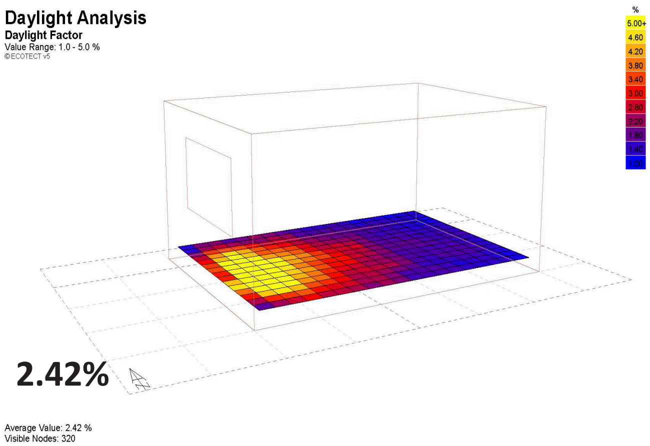


Figure 37. Daylight analysis for patient room in June

Figure 38. Daylighting analysis for patient room September

Office simulation:



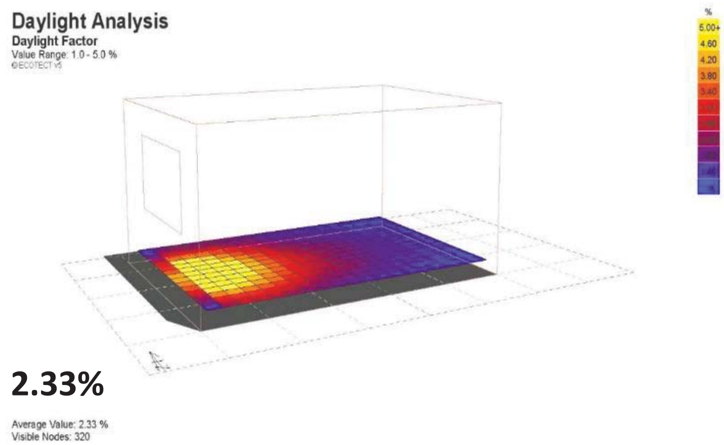
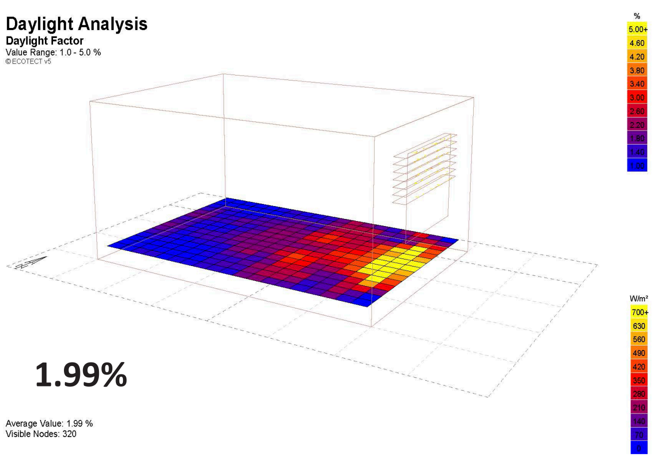


Figure 39. Daylight analysis in June

Figure 40. Daylight analysis in September

4.1.2 Analyses with shaded devices

Patient room simulation with shaded devices:



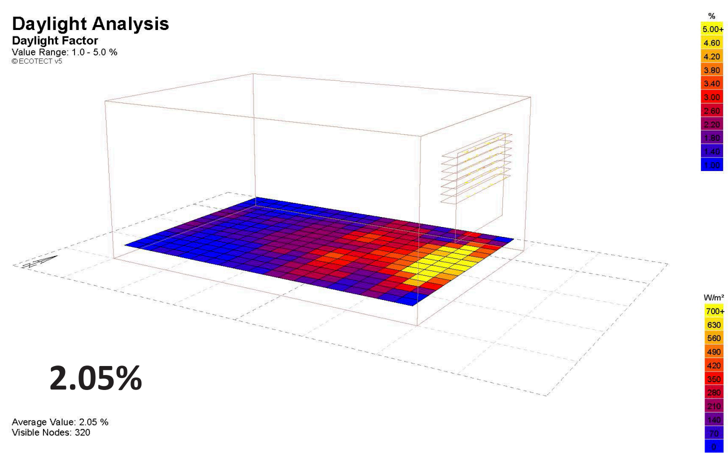
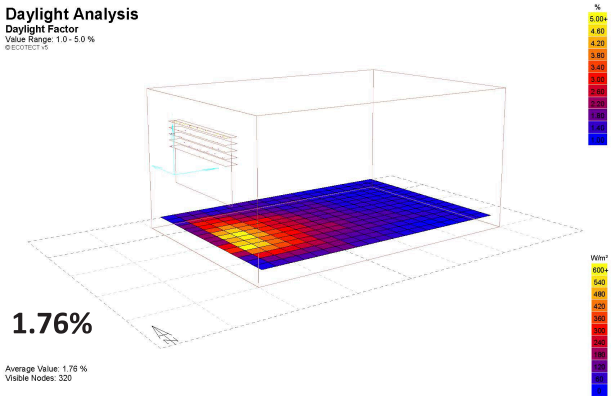


Figure 41. Daylight analyses after shaded divices implementation (9am June)

Figure 42. Daylight analyses after shaded divices implementation (12am June)

Office room simulation with shaded devices:



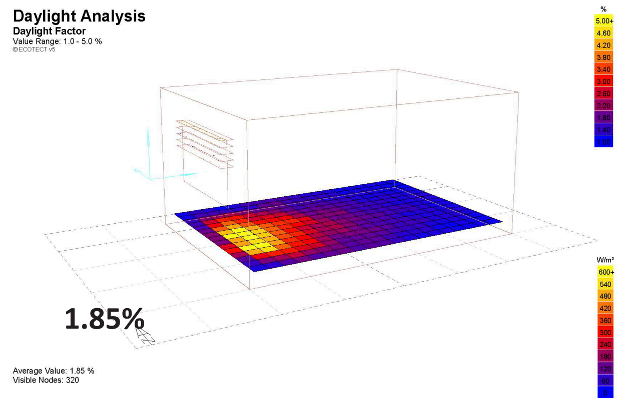


Figure 43. Daylight analyses after shaded divices implementation (9am June ***)***

Figure 44. Daylight analyses after shaded divices implementation (12am June ***)***

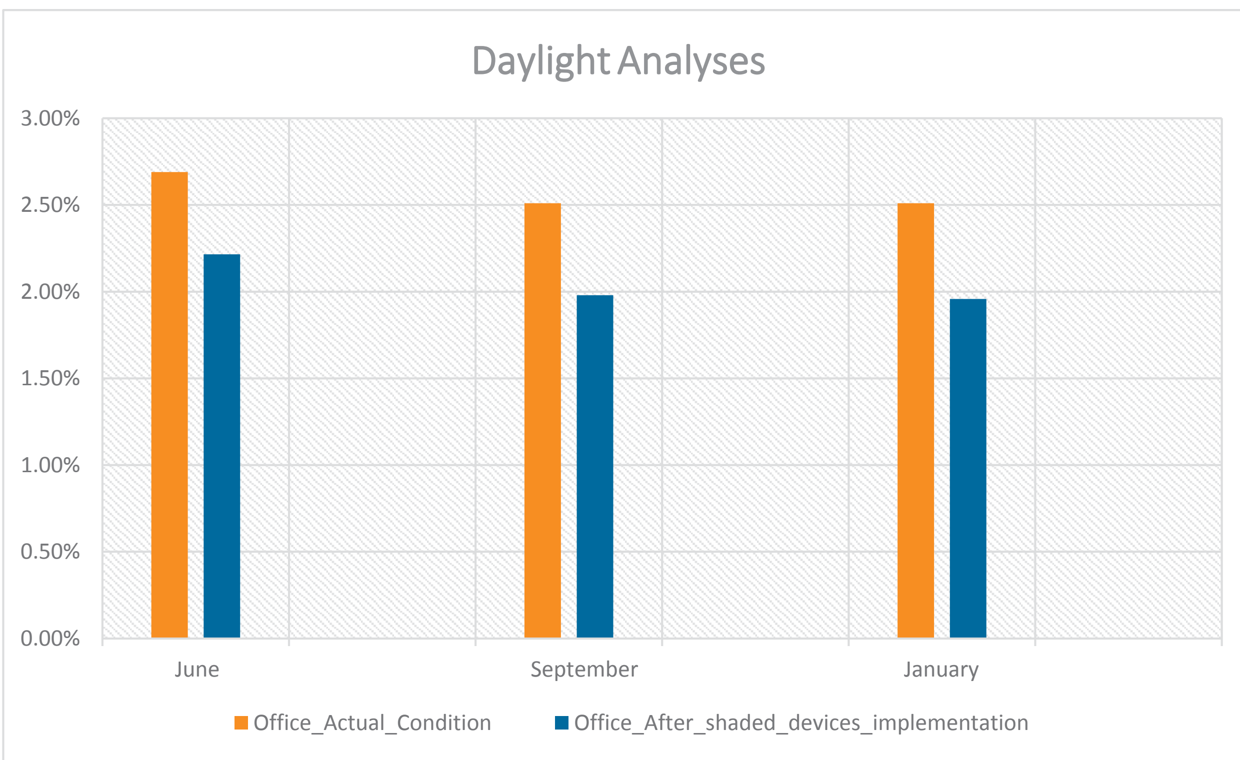


Table 3. Patient room before and after shaded divices implementation

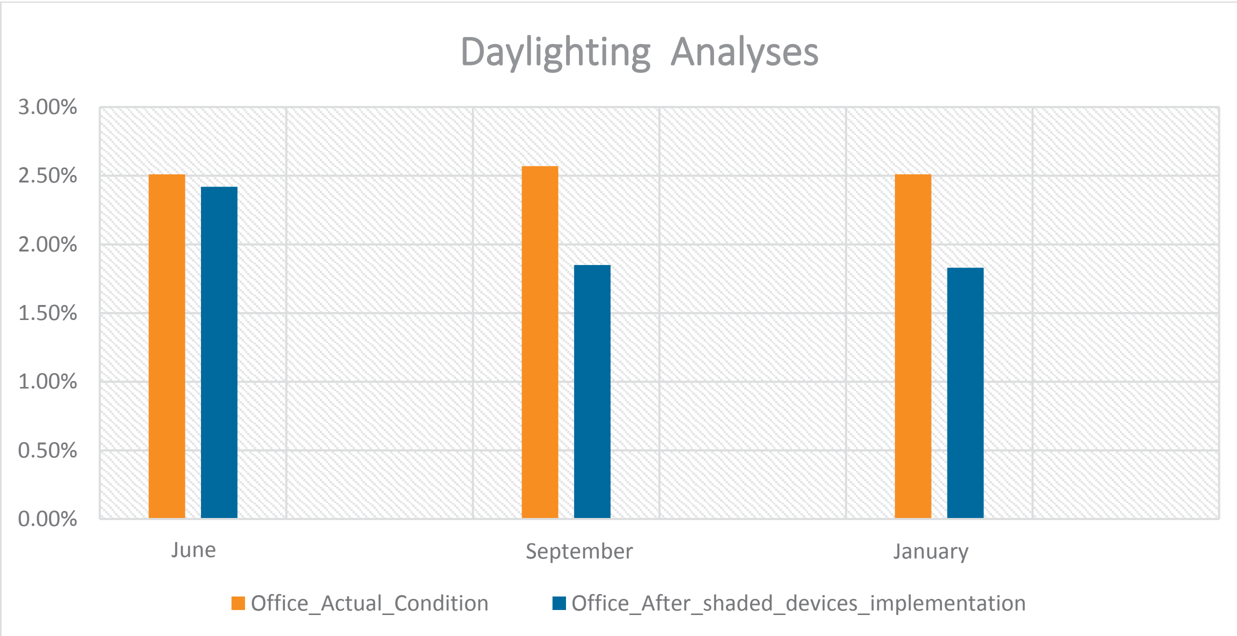


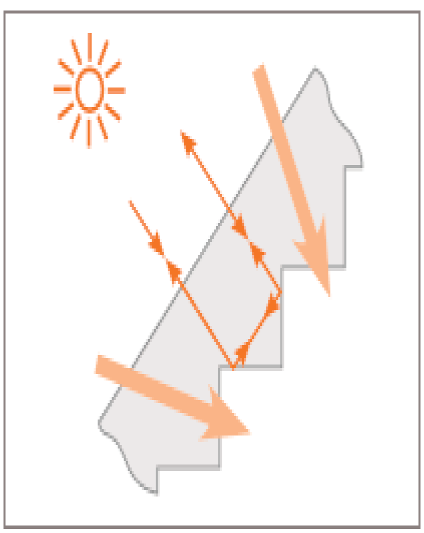
Table 4. Office room before and after shaded divices implementation

The different simulation scenarios conducted on the office and patient room, show that the main problem both rooms are facing is high exposure to daylighting in specific times of the day. For instance, the west façade has low daylighting rate till midday and then high exposure to sunlight. In contrast, the east façade is overexposed till midday and then faces low level of access to natural light for the rest of the day. The simulation program was useful to determine that the early assumptions were right, just Ecotect further specified the critical points. In the Figures are shown some analysis performed with Ecotect in order to specify the type of shading needed, its position and dimensions. The different analysis of the shading system determined that the device should have the same dimension as the window, as that area has the highest sun exposure percentage. Figure 49 and 50 shows a comparison of sun exposure before and after the shading system is implemented.

Furthermore, proper design of the shading system improves the thermal comfort of the users, allowing appropriate amount of daylighting inside the space without causing glare or discomfort..

4.2 Recommendations

To solve the daylighting issues that is causing discomfort to the users, based on the literature and case study reviews, the researcher evaluated that the best daylighting device that will reduce glare and maximize the daylight exposure is usage of movable prismatic shading plates. This device offers maximum solar protection and allows the control of daylighting (automatically or from users). The incident sunlight from another direction is captured by the movable panes and then reflected into the depth of the room. Also, the panels have a lamellae coating that reduces illumination in the windows and provides a suitable place for working or reading on the computer screen. The prism system is equipped with a sensor that controls the sun position and gathers weather data in order to maximize daylighting exposure in different climate conditions *(Figure 50)*. As shown in Figure 50, the plates are fixed into a frame which has electronic and mechanical sun tracking. (*Figure 51),* shows that the prismatic system is suitable for both façade and roof installations. The plate's glass is made of transparent acrylic glazing and is resistant to weather factors.



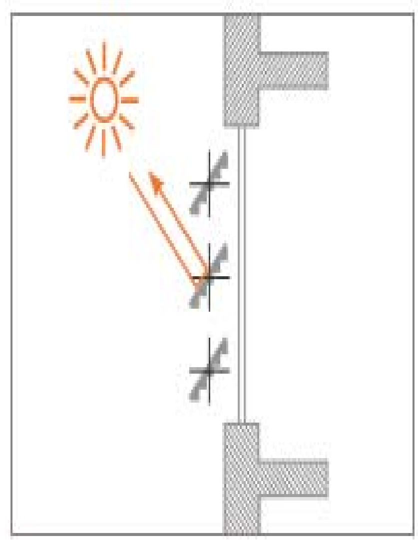


Figure 45. Sun angle trackin
Figure 46. Robust movable prism system
Figure 47. Facade positon section

After the implamentation of the recommended solution we have a beter daylight analyses result as shown in the *(Figure 53)*, tested by the help of Velux application. As result prismatic shading devices control the combination of direct and indirect sun light during the daytime by reduceing glare and maximizing the daylight exposure. The Prismatic shading device also protects the space from direct sun and overheating in summer and reduce the cooling loads of the building by 23%-46%. As a result, the appropriate use of a shading device in a window contributes aslso energy savings.

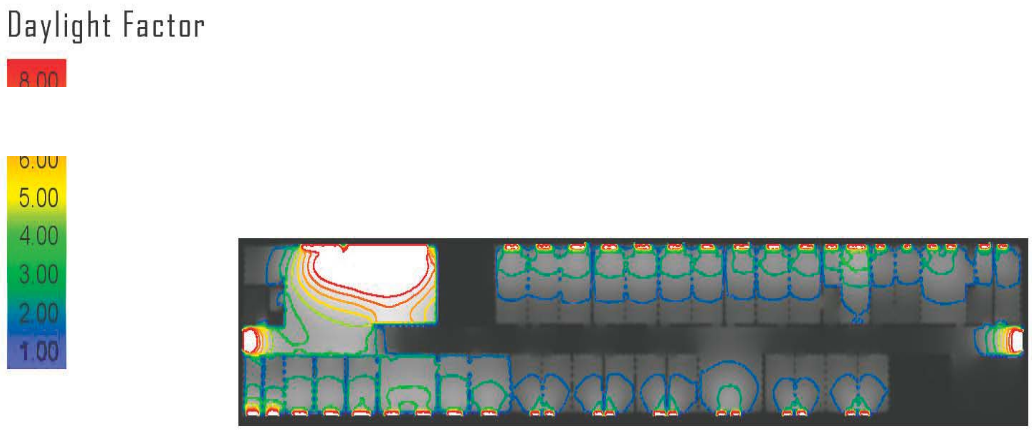


Figure 48. Daylight analyses whole floor after recommended implementation

CONCLUSION

From the research conducted, the main points that need to be emphasized are:

1. Designers should consider daylighting at the early stages of design, as it can be crucial in: determine the windows opening, better direct interior spaces and increase access to natural lighting.

2. The usage of advanced architecture techniques and simulation tools, would contribute in increasing the daylight level in interior spaces and reducing the thermal loads and energy consumption.

3. The wide range of simulation software can be a useful tool in calculating and designing daylighting, due to their high accuracy, clear and comprehensive analysis. The results can be shown in different chart forms and can be used during the whole process of design.

4. Designers should analyze the behavior of natural light throughout the year, to better understand how sunlight will affect the interior spaces in different seasons. Extensive simulations can prevent design problems at the early stages of design, which is easier and cheaper.

5. Ecotect is capable to simulate any building anywhere in the world by choosing the accurate location. Also, the program is freely accessible and easy to use due to the available tutorials in the internet.

6. Architects in Albania should be more concerned about sustainability building concepts, which will contribute in increasing the energy efficiency, comfortability and quality of life.

7. If future building design will be led by the concepts of sustainability, Albania and other countries can reduce the production level of electric power from non-renewable sources and maximize the usage of renewable sources such as sunlight.

8. Despite daylight, also natural ventilation is an important sustainable component that should be considered at the early stages.

9. Designers should aim to increase the daylight rate in interior areas and usage of natural ventilation in order to reduce the operation costs of the building such as artificial lighting, air-contingent and electrical power.

Furthermore, the research focused on the existing conditions of hospitals in Albania. Also, they have a significant contribution to the national energy consumption. This paper analyzed on of the hospital building in the Nene Tereza Hospital Campus. After summarizing its main problems and properties [size, building form, orientation] , the researcher conducted several simulations to better define the adequate solution. After the simulations, the researcher proposed 2 types of advanced shading elements that can be an effective solution to: a] maximize natural lighting access in poor lit; b] reduce glare and increase users ability to control light; c] provide the needed access to natural light and not obstacle access to nature.

This paper has confirmed that it is possible to improve the quality of interior areas and reduce glare or overheating by using advanced designing tools and daylighting technologies. In the chosen case study was helpful to understand that the appropriate shading element, glazing, and illumination control, can improve the quality of patients rooms and offer better working conditions.

5.2. Future works

The research topic has a lot of potential for future works. Firstly, it can be extended to other types of buildings such as office buildings, factories, schools, residential buildings etc. Most of this building typologies have issues with daylighting design, poor lighting quality in interior spaces, overheating during summer and lack of natural lighting during winter. The researched advanced technologies in terms of shading elements together with Ecotect provide the necessary framework for analyzing and improving the quality of daylighting design in future design or in retrofitting cases. Secondly, as explained in chapter 3, Ecotect can be used to calculate a variety of elements that can contribute to designing sustainable buildings. So, future research can focus in all aspects needed to design a sustainable building. Finally, the current research can be extended in analyzing the whole Nene Tereza campus and other important hospitals in Albania. This research can help in creating a database of current situation and serve as a basic framework for future retrofitting projects.

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APPENDIX A

QUESTIONARY

Studim si te përmirësojmë cilësinë dhe aksesin e dritës në spital

FALEMINDERIT PER PJESEMARRJEN

Pyetësori i mëposhtëm i drejtohet qytetareve dhe punonjesve te spitalit. Te gjitha informacionet e mbledhura do te mbeten anonime. Ky pyetësor zhvillohet ne emër te Epoka University për një disertacion, i cili ka për qellim investigim si te përmirësojmë cilesine e drites dhe hapsirave ne spitalet shqiptare.

1. How do you evaluate the level of daylighting in this hospital?

Very Good Good Poor Bad

2. Do you have complaints about the direct sunlight glare or overheating?

Yes No

3. Do you have access to natural lighting in your working area/room?

Yes No

4. Are the offices/patient rooms suitable for reading on the screen, data shows or other activities that require control of the levels of natural light?

Yes No

5. Is lighting controllable by the users?

Yes No

6. Is there a pleasant view to look at?

Yes No

7. Do you have complaints about the inadequate artificial light?

Yes No

8. Are their complaints about glare [for exmp. on computer screens]?

Yes No

9. Is your hospital's lighting bill unusually high?

Yes No