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Glass Surfaces for Benefits of Daylight in Social Housing

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Abstract. Internal environment and appropriate natural lighting of the building interior largely affects the health status and course of treatment of patients with psychiatric diagnoses such as depression, Alzheimer and disorder of functions. In particolar, this paper aims to show how smart glass surfaces, allowing the entry of natural lighting, can better support therapeutic process. It is important to elaborate knowledge for optimized lighting conditions in different healthy populations as well as in patients suffering from visual impairments and circadian rhythm disorders. To contribute to the development of new technologies about smart glass surfaces related to various aspects of light conditions for different populations and patients. In the process of preparation of architectural guidelines, it is essential to summarize the findings of the researchers, technologiest, designers, doctors and other related professionals working in particular environments and based on their incentives to specify requirements the architectural or technical design of the space for elederly people.

Introduction

Nowadays, the demand for housing has changed, not only in the quantitative aspects but especially in the qualitative dimension. Over time, above all in relation to socio-economic phenomena, the most vulnerable social categories have changed, now mainly represented by the elders. In addition, with the raising of the threshold of mortality, there has been a considerable gradual and steady increase in cases of dementia, a disorder of the intellectual functions previously acquired such as short and long-term memory, abstract thinking, the critical capacity, language and space / time orientation. The wide and increasing prevalence in the population, and the limited effectinevess of available therapies and the huge resources necessary to the management (social, emotional, organizational and economic) make the senile dementia one of the diseases with more severe social impact all over the world. The need to build housing for older people affected by dementia is related to the need for projects in which social, environmental and economic sustainability are conjugated to get buildings that can ensure urban and architectural flexibility for future development. Therefore, the basic structural modularity such as to allow easy expansions, the compositional and structural clarity to facilitate any possible aggregation between the minimal units, the adequate design of the building envelope (Fig. 1) and still the application of passive and active technologies for the environmental control are indispensable. In particular, with respect to the envelope building design, the transparent surfaces have a fundamental role both because they favor the entry of natural light [1], both because they allow the visual connection between the interior and the exterior of the building. Several researches are studying the state of health, happiness and well-being associated with the use of glass; particularly important results have been achieved in the health field, along with studies concerning the natural light inside the houses. Therefore, one can understand what an important role the sunlight into buildings for elederly people can play. During the first twenty years of the XX century it has been increasingly recognized in the design of Hospitals and Care Homes an architectural language and forms of expression focused on exploitation and celebration of the virtues of natural light in buildings was promoted by architects such as Le Corbusier: the *fenetre en longueur* is not only a pure technical device, but an architectural idea that brings to perfection the lighting issues (Fig. 2).

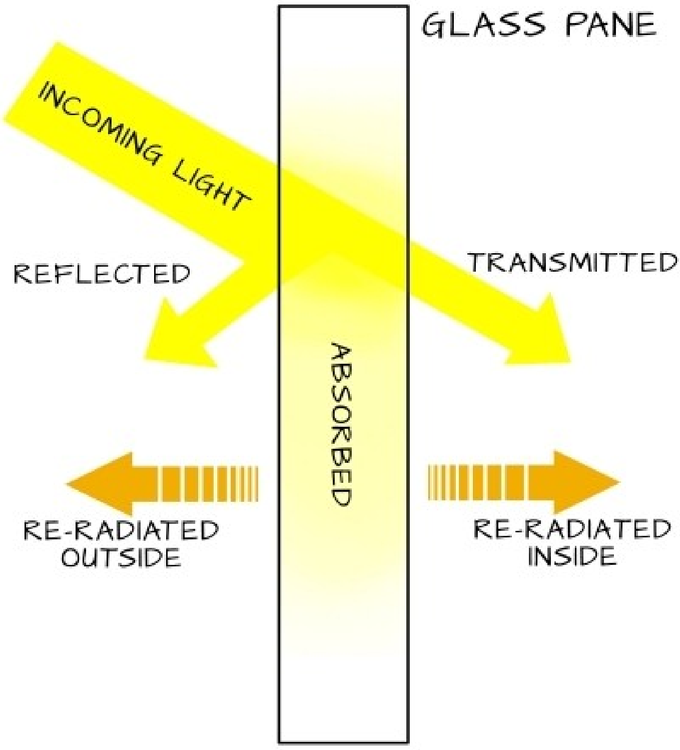

Figure 1. Energy flows of the building envelope through a window.

Figure 2. Paris, Villa Ozenfant by Le Corbusier (1922).

Methodology

Day lighting concepts - It is important to appreciate that the day lighting design process involves the integration of many disciplines including architectural, mechanical, electrical and light installation. A basic visual acuity and the working conditions have to be respected to achieve an effective day lighting design. More often visual comfort is discussed in the negative terms of discomfort glare, disability glare and veiling reflections. High levels of these three conditions result is visual discomfort and lower productivity.

Glare: the aim of an efficient daylighting design is not only to provide sufficient luminance levels to reach good visual conditions but also to maintain a comfortable and pleasing atmosphere. Glare or excessive brightness and contrast within the field of view can cause discomfort to people.

Veiling reflections: veiling reflections of shiny surfaces by bright light sources can be annoying, can super impose visual targets and, thus, reduce contrast. Some contrast in brightness levels may be required for visual effectiveness. Dull uniformity of lighting can lead to tiredness and lack of attention. Often, a good daylighting solution will integrate beams of daylight which stimulates the visual interest and helps to lead people in a building. The main advantage of using natural light is the reduction of power consumption of artificial lighting during daylight hours. Glass elements also provide a more interesting and pleasing view of the building and subdued lighting allows views inside the building at night.

The prosthetic environment - The living environment of Alzheimer's patients and of other types of dementia must be remoulded on their specific needs, since the action of protection calls into question not only the people but also the building spaces. The purpose of architecture is to understand the needs of the user and help him to "recover / maintain" an effective relationship with his living environment. In every phase of the disease, the environment can offset or accentuate cognitive deficits and behavioral problems [2]. The environmental modifications do not change the natural course of the disease but they can reduce behavioral problems, psychotic symptoms and the functional decline. Therefore, it is possible to discuss of prosthetic environment: «Just as when a patient loses the use of a limb we think to intervene by building a prosthesis that allows the patient to resume ambulating, when a patient suffers from dementia gradually loses the different cognitive abilities, we must build a prosthesis that is as complex as more complex is the loss, which supports the patient in his relationship with the environment, human and not», this is the opinion of Dr. S. Vitali, of the Institute of Golgi Cenci at Abbiategrasso, in province of Milan [3].

Therefore, the design of the environment is an integral part of the overall approach to the treatment and care of people with dementia and it is fundamental to the quality of life. The space should contain therapeutic elements that facilitate the reading and the understanding of people with dementia and provide a sense of security and comfort. Thermal comfort concerns the use of passive / active technology for environmental control: external air movement and temperature fluctuations should be adjusted in order to have a positive effect in the environment. During the winter months the heat gains can be used to create benefits in the interior spaces and at the same time the dispersion of heat should be prevented. The same principle applied for controlling the air exchange process can be extended to the case of the moisture regulation and levels of light in the environments. Most of the applications influence the shape of the buildings and the building envelope design. It is possible to differentiate between direct use or passive and active or indirect use of natural resources. The direct use is based on simple physical principles; for example, the natural ventilation can be induced by differences of temperature. As well, another example is the use of solar energy to heat the rooms: short waves penetrate through the transparent surfaces of the building envelope and are partially absorbed by the walls and interior floors that release heat. Due to the low transmission of long waves through the glass, the heat can get trapped in the room. The ventilation and passive heating systems provide the ability to create climate-controlled greenhouses or atria [4]. The solar energy indirect use requires special installations to collect the radiation and convert it into heat or electricity. Components of this type include collectors, heat pumps and storage systems to generate hot water or to heat the rooms. The integrated use of active and passive techniques for cooling and heating can determine an appropriate microclimate with energy savings.

Daylight and quality of life - Numerous studies have shown that health, happiness and wellbeing are inextricably connected to the daylight. Natural sunlight has a lot of benefits, from the synthesis of vitamin D to the impact on the neuroendocrine system. The dependence on the daylight is of particular relevance to synchronize our biological clock and to establish a circadian rhythm. Before the Seventies, few studies have been conducted to determine if the levels of natural light had influence on health or happiness. A breakthrough came in 1987 with the publication of a research's results of a team led by Dr. Alfred Lewy at the National Institute of Health. A further paper was published in 1984 by Dr. Norman Rosenthal who coined the term "SAD", Seasonal Affective Disorder, to describe the symptoms of lethargy, drowsiness and low concentration levels that are experienced by some people during the winter months. These results have led to forms of treatment for sufferers of SAD with the use of light therapy [5].

Today we are left with a heritage of buildings built in the last seventy years, which is based on artificial lighting interpreted by the pineal gland as darkness, and energy-intensive systems, which deny to those who live there the beneficial and healing qualities of daylight. Many of these buildings also have a negative impact on human health, productivity and well-being. This fact, for many occupants, leads to high levels of stress and, in extreme cases, the buildings are responsible for debilitating health problems associated with so-called Sick Building Syndrome (SBS). People affected complain of general disorders such as headache, tiredness, malaise, dizziness and difficulty concentrating [6]. Once people affected leave the building, the disturbances decrease. The problems associated with the SBS and the deprivation of daylight, along with the renewed interest in the use of natural lighting in the low-energy sustainable building design are now addressing many technologists and designers to consider innovative ways to exploit and harvest the benefits of sunlight, reducing the negative impacts associated with excess heat associated with it. It is extremely important that the positive effects of sunlight are not confused with the negative ones due to excessive solar radiation, because modern glass surfaces can be able to reduce the transmission of ultraviolet rays.

In different types of buildings many benefits associated with the use of glass surfaces have been identified, mainly related the entrance of natural light, improving the spatial environment, the visual connection with the world outside the building and aesthetic value. Elderly people with dementia get beneficial effects from exposure to natural light, including the retrieval of biological rhythms or the overcoming of insomnia and seasonal depressions. It has been demonstarted that the light causes a reduction of the symptom called crepuscularism, that is the fact that patients get confused and nervous at sunset. Dr. Philip Sloane and his team have discovered that residents in structures with low levels of light show higher levels of agitation [7]. Exposure to the morning light reduces agitation in patients. When the elderly people with dementia were exposed to 2,500 lux for two hours in the morning, for two periods of ten days their agitation was reduced. In fact, patients were significantly more nervous in the days without treatment. Thanks to these studies it can understand what is the importance of natural lighting, preferably with a view of natural environments.

Experimental and results

Elements for design - The creation and experience of the comfort of light is the result of several subsystems that affect the building at different levels: the context, the forms, the interior and the envelope. With regard to the context, to increase the light level may act by limiting the obstructions, making proper use of natural elements and increasing the reflection coefficient of the elements that hide the sky. Another way is to work inside of the building, reducing the opaque internal partitions that limit the propagation of light and using light colours, to help its spread. It is possible also work on the envelope, through the light-connection elements between exterior and interior, by locating the light sources in the direction in which the external brightness is greater and using the most suitable device in relation to the type of equipment around. The proper positioning of the openings may promote greater illumination in the morning hours, more effectively than in the afternoon. The glass surfaces should also be in a low position in the bedrooms so as to favor the view of the outside landscape also by lying (Fig. 3). The need of entry of the solar light into the interior of buildings and to ensure specific conditions have determined a constant evolution and innovation of devices for natural lighting, which can be divided into three different categories of components: passage, driving and control of the sunlight [8].

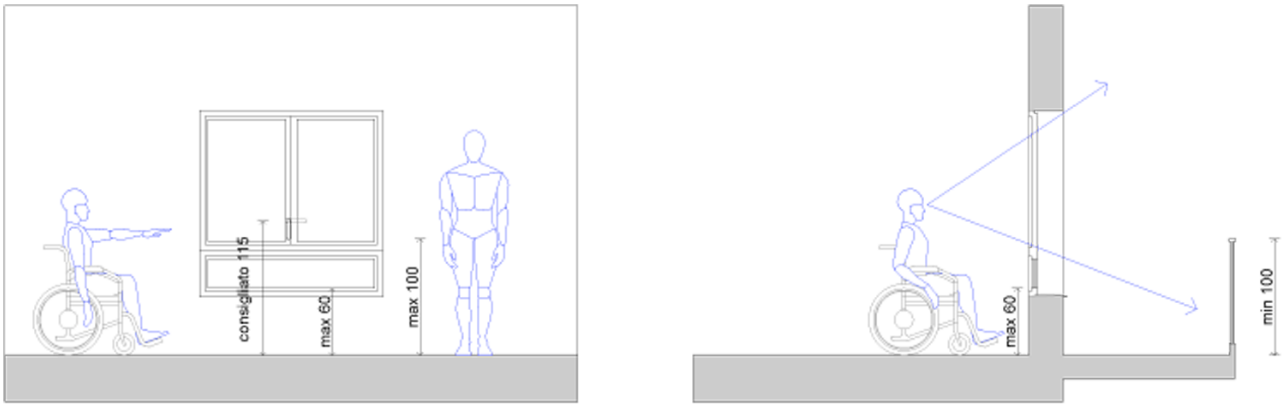

Figure 3. Compositional scheme of the windows with the different possibilities of view on the outside according to the user needs.

Figure 4. Social housing for elderly people, Alcacer do Sal, Portugal, project by Francisco and Manuel Aires Mateus (2011).

The passage components allow natural light to pass from one environment to another: windows, patio doors, skylights, domes, sheds, etc. The windows are the most simple and usual systems for the passage of natural light and their dimensions are linked to those of the environment to be illuminated (Fig. 4). Domes, skylights, sheds are systems to illuminate from above especially large environments and allow to obtain an excellent uniformity of illumination [9]. Thanks to the use of materials and systems that reflect direct sunlight, it is possible to limit or eliminate potential glare and overheating problems. There are conduction components that guide and distribute the light radiation inside the building such as loggias or galleries, porches, patios, atriums, greenhouses, light pipes, fiber optic systems, etc. The gallery or loggia (Fig. 5) is a covered space that can be closed by glass elements; it ensures stable light conditions, reducing the bright contrasts. its internal finish is very important because the diffusion of light in adjacent areas of a building depends on its colour. The porch (Fig. 6) provides a low-contrast daylight and rather stable and generates a protected environment from direct solar radiation; also in this case the internal finish is important. The court or the patio (Fig. 7) are spaces that allow the control of the natural light and its distribution inside the building.

Light colours increase the level of light inside them and their transmission capacity of light to lower floors of the building. The atrium (Fig. 8) is an element that can be covered with translucent or transparent material and allows the entry of a low-contrast light in interior spaces of a building connected to it with passage components. The atrium interior finishes have to be clear (in our latitudes systems must be provided which prevent overheating in summer). The greenhouse, which can represent a source of most effective passive capture, allows bright conditions similar to external ones and their control through the use of shielding and special glasses. The ducts of light (Fig. 9) are systems used to transport the daylight into areas that have no other possibility to be illuminated naturally [10]. Unlike the skylights or the sheds, the solar ducts, thanks to their shape and through refracting lenses, captan natural light and convey it into the rooms, allowing also the ventilation. The intensity of transmitted light decreases in relation to the length: the more the light duct is long, the more it reduces the amount of light at the exit. Typically the section varies between m 0,50x0,50 and m 1,20x1,20, with length up to m 15. The main objective of these systems is not the amount of light which goes into the interior but the quality of the incoming light. For this reason they are designed considering the solar trajectory and maximizing, thanks to their reflectance, the light transport. A special and still experimental field is the one that tries to bring light into buildings through materials and new technologies, such as optical fibers, light guides or sensors, light concentrators and heliostats.

These mobile systems use active systems for the harvesting and concentration of solar rays and are designed to be constantly oriented to the direction of the sun. The application of these systems for the transport of natural light can have multiple effects on the dimensioning and exploitation of spaces without openings, providing new prospects for the use of such spaces, also with the possibility of innovation of the traditional building types. Possible applications may include, in general, for discontinuous use environments that do not communicate directly with the outside. Interesting applications could include building restoration, in particular, the buildings of historical centers, where there are strong constraints and where the modification of the people needs requires the increase of the lighting level. These components, among the most innovative of management systems of light are still in the experimental phase, their cost is quite high and are not well integrated in the current buildings. The control components favor or limit the passage of light, possibly changing some properties such as colour, distribution, etc., thus allowing the management of the lighting level. The lighting control is the temporary or permanent, partial or complete exclusion of solar radiation from the interior spaces of the building. The need to control the flow of solar energy in a social housing occurs when the contribution of the solar radiation can produce an unacceptable indoor air temperature or in general discomfort to the occupants, due to direct contact between occupant and incident solar radiation or glare and visual discomfort or when it is necessary to remedy a not desired lighting level [11].

Figure 5. Assisted Health Residence, Carpi (Modena, Italy),
project by Ipostudio Architetti Associati, 1997 - 2001.

Figure 6. House for elders at Galliate (Novara, Italy), project by Antonio Monestiroli, Alessandro Colbertaldo, Antonio Paolucci, Paolo Rizzato, 1982 - 1989.

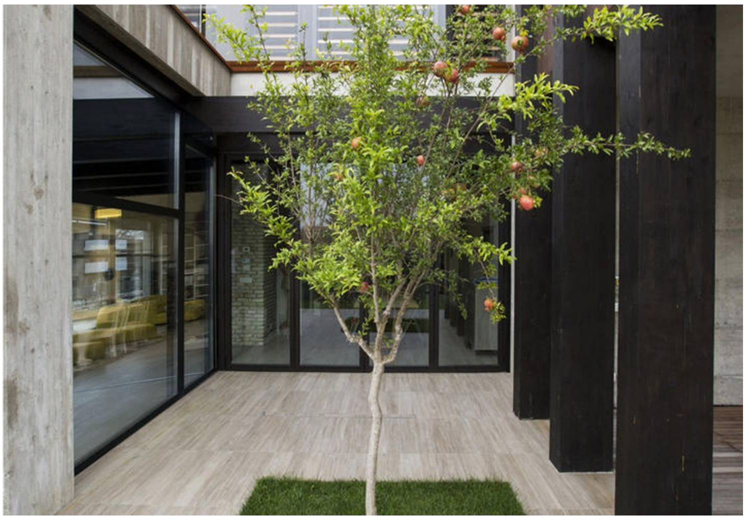

Figure 7. House with patio and large windows, Pieve di Cento (Bologna), designed by the firm of Giraldi Associates (2014).

Figure 8. Lost villa, Nairobi, project by Jonathan Woolf, 2009.

Figure 9. Scheme of a solar duct.

Glass properties - Control systems are the special glasses and the shield systems. Glass is a material with extraordinary properties of transparency to light, which allows to look through it and make a connection with the outside world, protecting from the weather. It is a strong and durable material, today also used as a structural component in many buildings. The glass influence regarding the thermal performance of the built environment is evident and companies and designers are constantly looking for new ways to improve its properties, to optimize the use of natural light in buildings, minimizing the energy needs for heating and cooling; furthermore, it constitutes an acoustic barrier between the space inside the buildings and the external environment. Even in the interior of the buildings, the glass partitions may represent a means to reduce the transmission of noise between the environments, while maintaining the entry of natural light and the view through. If on the one side of the glass allows the natural lighting, on the other it can cause glare and as radiating wall can create discomfort. The use of strategies for the control of thermal comfort linked to the use of glass directly involves also the aspect of the lighting comfort. The objectives of the lighting control are: to allow the diffused natural lighting, excluding the direct solar radiation such as, for example, in environments with permanent daytime-light requirement; to exclude the solar radiation when the illumination is not necessary [12].

Today, there are on the market many varieties of transparent and semi-transparent products, aimed at a reduction of the solar and / or thermal transmission. The trend is towards components able to select the wavelength range of the radiation of which we want prevent the entry in function of the microclimatic conditions. The choice of the type of product depends on the microclimatic conditions of the site, orientation, design features, as well as on the intended use of the space in which the transparent closure is placed. In all cases, the transparent components offer diversified performance for the control of the incident radiation, to prevent it from producing an excessive contrast or a glare condition. There are effects that are produced both with the direct component of the sun or with one widespread, particularly in the case of a clear sky. There are two types of light control: *passive control*, with reduction of lighting level and maintaining of luminance uniformity with the action on the building envelope; *active control*, with the use of artificial lighting devices that use electricity. The main passive control systems of daylight can be divided as follows [13]:

- *Simple reflection*: these are devices that reflect direct solar radiation. These systems are designed for thermal protection, but also for controlling the glare. There are for example coated glasses that reflect the wavelengths across the entire solar spectrum, which greatly reduce the light transmission and glare. These types of glass lead to a reduction of light radiation, but outside have a mirror effect, not suitable in the case of residences for people with dementia. The printed glasses, however, are printed using silkscreen (a powdered ceramic compound, fried, that is applied on a side of the glass by reproducing the pattern to be printed). The cooking in the oven, generally associated to the

hardening or thermal hardening of the glass, by vitrifying the mixture, determines a permanent coating, an enamel which absorbs and reflects the solar energy.
- *Complex reflection*: there are devices able to selectively shield the light radiation. This category includes the coloured glasses that keep their transparency inside, even if the brightness of the outside view is reduced and the perception of colour changed. The most common colours are neutral gray, bronze and blue-green that not much alter the perceived colour and tend to blend well with other colours of the architecture. A great evolution is represented by the application of low-e coating. They tend to keep the heat on the same side from which it originated and, at the same time, ensure a good transmission of visible light. There are also dynamic control of solar energy self-adjusting systems that modify the optical properties and colour depending on the intensity of solar radiation: self-regulating material (photochromic, thermochromic) and electrically activated (electrochromic, liquid crystal, Transparent Insulating Materials, etc.) and coatings to selective angular behavior, which have the property of modifying the value of transmittance depending on the angle of incidence of the direct radiation.
- *Disseminatio*n: there are systems that filter and spread the indoor direct incident radiation, such as matting films, transmit light but they do not allow the exterior view.
- *Diffraction*: there are devices that filter the entry of solar spectrum. The main types are constituted by reflective films, which have the property of strongly reduce the reflection of light on the glass surface, and by holographic films. Holographic systems are considered between those solutions that make better use of daylight both in overcast conditions, both during time of solar lighting direct, allowing to obtain an improvement of the daylight illumination distribution by means of the controlled deviation of solar radiation. These are transparent films on which thin geometric designs printed diffract and guide the light in a specific direction and, therefore, do not transmit the direct light. A single film can contain the instruction for four different angles of incidence and must be protected between two sheets of glass.
- *Refraction*: there are devices that allow the refraction of radiation by changing the distribution of light and transforming the direct sunlight in diffuse light. For example, the prismatic films deflect the solar rays according to the angle of incidence with which they are affected and allow to direct the light where it is needed. The incision technique allows the production of films with tiny prisms that are spaced one millimeter; these films are very thin and light, and for protection from scratches or dust, they must be enclosed between two plates of a normal double glazing.
- *Conduction*: there is conduction when solar radiation is deflected in prismatic elements by total internal reflection and refraction. The panel controls the glare, eliminates the difference in luminance and produces a limited visual distortion. An example is constituted by the laser-cut panel that contain many small mirrors that redirect light to the ceiling rather than toward the floor: a light directed toward the floor is wasted as heat and gives a little illumination and reflected light; in contrast, a light directed to the ceiling is reflected downward by providing a helpful diffuse illumination. Technological innovation has led to the development of products with excellent performance, with a wide range of possible settings, with advanced production techniques and the use of computer systems for a correct positioning of the slabs. Among the most recent examples of applications there is the Agbar Tower (Barcelona, 2005), designed by Jean Nouvel (Fig. 10). The slope of every pane of glass that makes up the cladding has been calculated in relation to the sunshine. The types of plates range from transparent (valuable views and cavities), the translucent printed (predominant type), the screen-printed with sunscreen (dome), until the glass with integrated photovoltaic cells for obtaining electric energy. The screen printed elements have a gradient of variation depending on the angle of incidence, which varies by a darkening of 40% up to 80% [14]. Other control components are the shielding systems, devices that work as regulatory barrier of solar radiation, without preventing the lighting and ventilation of the interior. The choice of the adequate shielding system provides a careful and accurate design that takes into account the orientation, extent and form of the building, of the individual surfaces to be screened, the specific climatic conditions of the location and the surrounding environment, including the study of the path of the sun in the different seasons and at different times of a day. They can be of various types and

mainly are divided into two main classes: fixed and mobile systems; each of these two classes includes two sub-categories, depending on whether the systems are made up of vertical or horizontal elements. In the design phase it is necessary to think not only to increase the amount of natural light but also to manage it properly, through the passage and control components of sunlight, or through proper predisposition of indoor environments that need to be properly oriented, according to the activity that takes place there.

It is necessary that the size, the shape and the colours have to be studied; for example, a smooth white wall can reflect 85% of the incident light, a cream-coloured wall about 75% and a yellow wall only 65%; bright colours, like orange, absorb about 60% of the light that hits them. Many parameters have to be considered, but only through the use of software that simulates the brightness inside the rooms, it is possible to see the effects under varying sky conditions and to evaluate the glare and the impact of light in the presence of different materials.

Figure 10. Agbar Tower, Barçelona, project by Jean Nouvel, 2005.

Experimental and results

Electrochromic materials for smart windows - There is a project carried out in cooperation with the Federal Commission of Technology and Innovation in the framework of WP1 of the Swiss Competence Center for Energy Research called “Future energy efficient buildings and districts”. This activity is centred on the development of next generation electrochromic switchable glazing technologies. Even though smart windows based on electrochromic coatings are on the market today, there are still several major drawbacks with existing technologies (Fig.11). The switching speed is slow; the optical response of switching has to be improved with respect to contrast and speed [15]. In addition, the durability of devices based on liquid or organic electrolytes is not yet satisfying, which requires the development of systems with increased cycling stability. Innovative approaches for switchable optical coatings, such as novel nanocomposite electrochromic transition metal oxide layers combined with new solid ion conductors and chiral liquid crystals, open new perspectives for more durable smart glazing with faster optical response (Fig.12). The objectives currently pursued within this project are the development of novel nanostructured materials for switchable windows, their characterization and the prediction of their performances [16].

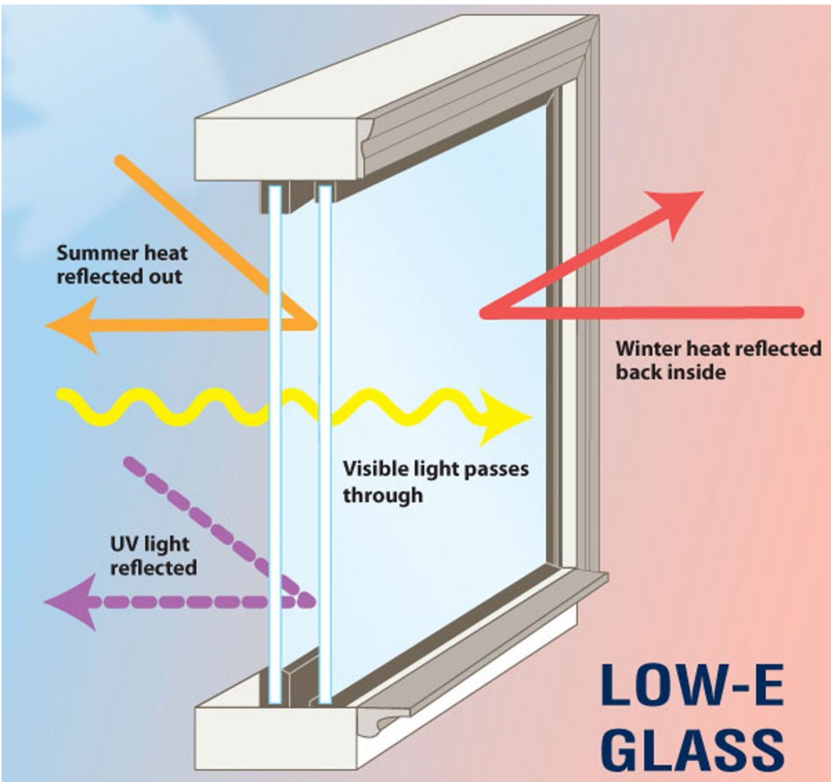

Figure 11. Scheme of a section of an electrochromic window.

Figure 12. Window with electrochromic glass.

The new glass for smart "window" - At Lawrence Berkeley National Laboratory in Berkeley, California, a team of researchers led by Delia Milliron, has developed a new technology that allows to obtain a particular type of glass that can work dynamically controlling the flow of heat and light which passes through it, modulating it according to different weather conditions, through the transparency. The new glass of this type of smart window exploits the interaction of two highly conductive materials: the nanocrystals of indium oxide and tin, and a glassy matrix of niobium oxide; the interaction between the two conductors allows a selective control of visible light and heat, so as to obtain natural lighting inside without increase of heat, typical of the hottest months.

Compared to current technologies, in which the control of the radiation also leads to a darkening of the glass surface, carrying some drawbacks about quality of the lighting of the environments, the conformation in three layers of the smart window allows the user a personalized and optimal control of heat, of light and transparency. In a perspective of energy saving, this new approach would allow a considerable saving of resources and optimal management of costs, especially for cooling and lighting in residential buildings and in particular of the commercial ones, where the use of large glass is widespread [17].

The use of this type of glass may be suitable for windows in a residence for the elderly. From the point of view of the study of materials what is most important is that they were able to demonstrate that it is possible to combine very different materials to achieve new properties that can not be achieved with single-phase materials. The interaction of the two materials makes it possible to block approximately 50% of the heat and 70% of visible light compared to the use of the individual materials. Since 2013, the researchers are working with a start-up based in Oakland, California, to lower production costs, still too high. One possibility would be to use the crystals in the zinc base in place of expensive indium oxide and tin, experimentation that is giving good laboratory results. A simple window can also perform functions of energy supply, as a solar panel. This is shown by the research on “Large-area luminescent solar concentrators”, made by a research team from the University Milano-Bicocca in collaboration with the Los Alamos National Laboratory (U.S.A.). The team has developed solar concentrators: these are simple slabs of plexiglass “doped” with special fluorescent nanoparticles that capture and concentrate sunlight transforming the windows of buildings in clean energy generators, without giving up the transparency of the material [18].They consist of a semitransparent glass or plastic waveguide doped or coated with highly emissive chromophores, which upon absorption of sunlight re-emit photons at longer wavelengths. Total internal reflection guides the luminescence to the waveguide edges, where it is converted into electricity by PV cells installed along the slab perimeter (Fig.13).

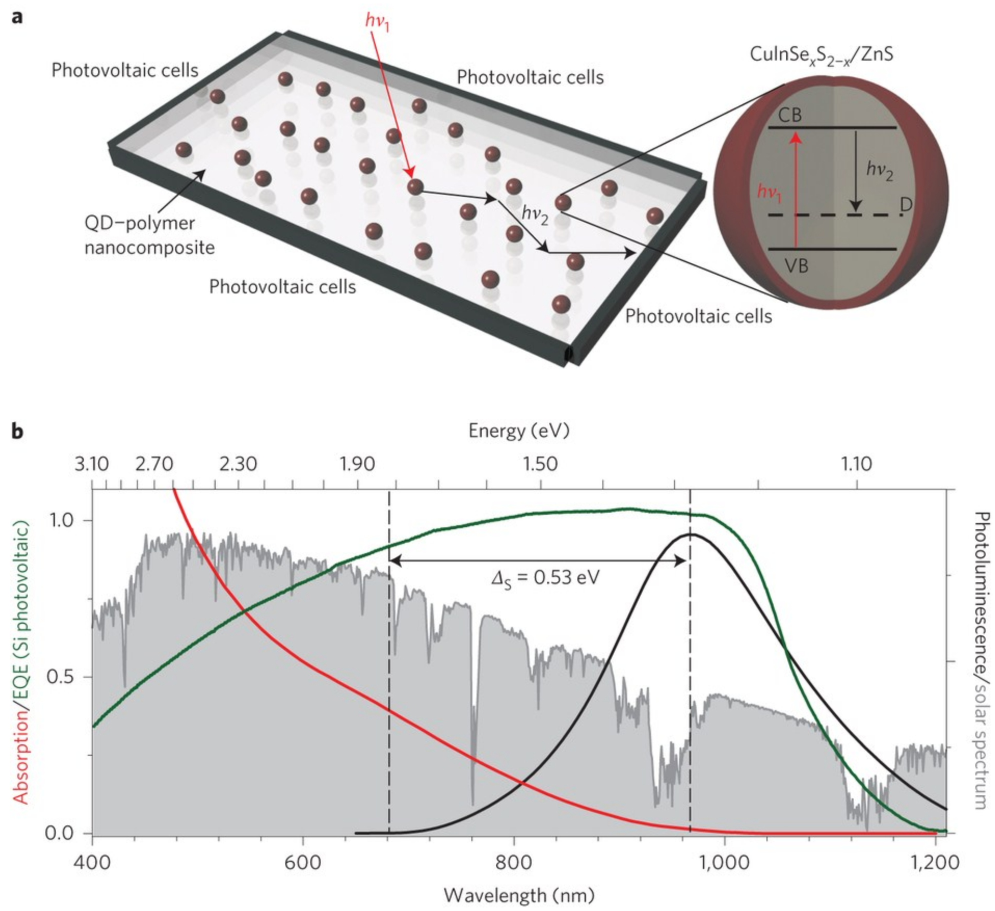

Figure 13. A schematic of an LSC composed of highly emissive choromophores in a plastic slab coupled to photovoltaic (PV) cells at the slab edges.

Conclusions

The entry of natural light in the environment is an essential condition for not only visual but also psychological well-being. Numerous studies have also shown that the use of glass in buildings has profound positive implications on quality of life, happiness and sense of well-being, health, learning and productivity. In addition to allowing the view, the windows closures allow the entry of natural light that, unlike artificial lighting is healthy, changeable, interesting and informative. The article shows that how with new technologies and thank to continuous researche in progress on smart glass surfaces it is possible to reconsider the primary role of natural light in buildings that can make them healthy, more comfortable and truly sustainable; In fact, the results of daylighting research described in this article have produced a greater understanding of the application and benefits that may be achieved utilising the improved designs which will hopefully be implemented into low energy consuming sustainable social housing, in particular in ones designed to weak users, as those of the elderly people in general and specifically to the elderly people with dementia. Daylighting is critical climate control components that should be considered for all building stock in efforts to reduce energy consumption and increase sustainability. Natural light has a crucial part to play in the sustainable buildings of the future and apply some practical building and design science theory could make a substantial difference to both the short and long term viability of businesses operating within the buildings they occupy. It could be said that the most significant outcome of this research relates to the collection of reliable analysis that can be used to design systems on scientific viewpoint.

Sources of photos

Fig.1 - document online: sustainabilityworkshop.autodesk.com/buildings/glazing-properties

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Fig.10 - by the Author.

Fig.11 - document online: composersrecordings.com/low-e-glass-windows.

Fig.12 – by the Author.

Fig.13 - document online: stokes-shift-engineered nanocrystals for next-generation luminescent solar concentrators.

References

[1] Baetens, R.; Jelle, B.P.; Gustavsen, A. “Properties, requirements and possibilities of smart windows for dynamic daylight and solar energy control in buildings: A state-of-the-art review”. Solar Energy Materials and Solar Cells 94 (2010) 87 - 105.

[2] De Giovanni, G. “Up3 Social housing per la terza età”. Aracne, Roma (2014).

[3] Faggian S., Borell E., Pavan G. Qualità di cura e qualità di vita della persona con demenza - Dalla misurazione all’intervento, FrancoAngeli, Milano (2013).

[4] Chiras, D. C., The Solar house: passive heating and cooling, Chelsea Green Publishing 2002.

[5] Avery, D. H.; Eder, D. N.; Bolte, M. A.; Hellekson, C. J.; Dunner, D. L.; Vitiello, M. V.; Prinz, P. N., "Dawn simulation and bright light in the treatment of SAD: A controlled study". Biological Psychiatry. 50 (3) (2001), 205 - 216.

[6] Murphy, M. "Sick Building Syndrome and the Problem of Uncertainty: Environmental Politics, Technoscience, and Women Workers". Kindle Edition (2006).

[7] Sloane, P.; Zimmerman, S.; Williams, C. S.; Reed, P. S.; Karminder S. Gill K. S. and Preisser J. S. "Evaluating the Quality of Life of Long-Term Care Residents With Dementia". The Gerontologist 54 (2005), 37 - 49.

[8] Li, D.; Cheung, K.; Wong, S.; Lam, T. "An analysis of energy-efficient light fittings and lighting controls". Applied Energy 87 (2) Academic Search Premier, Ipswich, MA (2010) 558-567.

[9] Wanda, L. "Lighten Up With Tubular Daylighting Devices. Tubular daylighting devices turn natural light into a deployable technology". EcoBuilding Pulse. Retrieved April 3 (2014).

[10] DeBellis, K. "Daylighting goes tubular". The Construction Specifier. Retrieved August 5 (2012).

[11] Caicedo, D.; Pandharipande, A.; Willems, FMJ. "Daylight-adaptive lighting control using light sensor calibration prior-information". Energy and Buildings 73 (2014), 105 - 114.

[12] Leslie, R.P.; Raghavan, R.; Howlett, O.; and Eaton, C. "The Potential of Simplified Concepts for Daylight Harvesting". Lighting Research and Technology 37 (2005), 21-40.

[13] Baird, G. The Architectural Expression of Environmental Control Systems. Spon Press New York (2001).

[14] Gutierrez, D.; Seron, F. J.; Sobreviela, E. J.; Magallon, J. A. "Lighting design in low-cost immersive systems". Proceedings of Computer Graphics International Conference, CGI (2004) 266-269.

[15] Azens, A. & Granqvist, C. J. "Electrochromic smart windows: energy efficiency and device aspects". Solid State Electrochemistry 7 (2003) 64 - 68.

[16] Bouvard, O.; Krammer A. and Schueler, A. "In situ core-level and valence-band photoelectron spectroscopy of reactively sputtered tungsten oxide films". Surface and Interface Analysis 48, 1 (2016).

[17] Di Salvo S., "Smart Materials in Architecture". International Journal of Engineering Research in Africa 23, Trans Tech Publications (2016) 72 - 79.

[18] Meinardi, F. et al. "Large-area luminescent solar concentrators based on Stokes-shift-engineered nanocrystals in a mass-polymerized PMMA matrix". Nature Photonics 8 (2014) 392 - 399.