Project co-financed by the European Regional Development Fund

TEESCHOOLS

Transferring Energy Efficiency in Mediterranean Schools

PRIORITY AXIS: Fostering Low-carbon strategies and energy efficiency in specific MED territories: cities, islands and remote areas

OBJECTIVE: 2.1 To raise capacity for better management of energy in public buildings at transnational level

https://teeschools.interreg-med.eu/

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POLICY RECOMMENDATIONS

ON ENERGY EFFICIENT SCHOOL BUILDINGS DESIGN

(D. 5.3.4)

FEBRUARY 2020

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Contents

0. Introduction

Global warming requires drastic measures to reduce uninterrupted energy production and, by extension, the emission of gaseous pollutants.

The need to save energy and protect the environment, leads us to the creation of modern bioclimatic - ecological school units.

The aim is the appropriate design, which will limit the building's dependence on mechanical equipment for heating or cooling.

To achieve a reduction in energy consumption in the winter season, we need to limit the thermal losses of the building and maximize solar gains. During the summer season, we seek the natural cooling of the building, by minimizing the thermal gains and discharging it through ventilation.

The two thermal flow units, to and from the building, make up its thermal balance.

This issue includes guidelines, guidelines and technical solutions for the bioclimatic – ecological design of school buildings, of all levels of education.

1. GENERAL PRINCIPLES

The main goal of this study is to design an energy efficient building that offers users a healthy and pleasant environment.

The operating cost of energy-powered systems such as lighting, heating and air conditioning depends directly on the original synthetic options. Thus concepts such as orientation, ventilation, insulation, sun and shading should be introduced simultaneously and as early as possible in the design process, without this negates the need to enhance natural lighting, ventilation and provide additional heating or cooling at certain times of the year.

Costly and energy-intensive mechanical support systems can be reduced to a minimum if the initial synthetic options have taken into account issues such as the location of the building on the plot, the basic form of the building, the layout of the premises, the type of construction, the building materials used and the desired quality of the environment inside and outside the building.

All buildings have a basic function: to enclose, with their shell, space that provides an interior environment suitable for the function they house.

In this light, the concept of "initial architectural conception and composition of the building shell" is extremely important. The building shell (external walls, housing, etc.) with its shape and the relevant selection of bodies and building materials prejudges and defines the bioclimatic and energy behavior of the construction.

However, in addition to creating the appropriate internal conditions, these buildings in turn give the opportunity to create covered, comfortable spaces around them that can be of considerable pleasant use at certain times of the year, especially for countries with a temperate climate like Greece. These outdoor areas can have a beneficial impact on the interior environment of the building by minimising the need for artificial heating or cooling. The famous Byzantine "solar" was such a semi-outdoor space of widespread use.

BIOCLIMATIC OPERATION OF THE BUILDING

It is the ability of the shell of the building, to create conditions of thermal and visual comfort, with minimal energy consumption.

Objectives

- Maximum possible energy savings
- Use of renewable energy sources

Applications

In order to achieve the above objectives, the following shall be used:

- Passive solar systems
- Hybrid Systems

- Energy solar systems
- Renewable energy sources

PHYSICAL ENERGY AND SALES

Passive systems provide the building with heating and cooling by exploiting natural energy sources.

An energy source is any element of the environment that contributes heat to a building, while the heat-absorbing element is a sink.

Basic energy sources for heating are:

- Solar radiation
- The external air temperature above 24oC
- Internal gains, conventional home heating and home lighting

Basic loss are:

- The sky and space beyond the atmosphere
- The external air, temperature below 24o C
- Wet surfaces and vegetation

A5. THERMAL EMPLOYMENT OF BUILDINGS

In passive systems, the elements of heat collection, storage, transmission and diffusion are integral parts of the architectural elements (walls, roof, etc.).

In other words, an architectural element, in addition to the delimitation of the space or the determination of the shape of the building, can also be used for heating or cooling it.

A6. CLIMATE DEFINITION

Climate knowledge is an important role in the design of a building.

This is characterized in:

Macro-climate: covers the general characteristics of the area (latitude)

Meso-climate: the general climate is tempered by local topography such as soil relief and water surfaces

Micro-climate: in the same location and small differences in vegetation and soil morphology, have a decisive effect.

Greece is characterized by the Mediterranean type of temperate climate and has mild wet winters and warm dry summers.

The country's climate can be divided into four main categories:

- Wet Mediterranean: [Western Greece, western Peloponnese, lowlands and semi-mountains of Epirus]
- Dry Mediterranean: [Cyclades, coastal Crete, 4000, eastern Peloponnese, Attica, lowland areas of Eastern Sterea]
- Continental: [Cyclades, coastal Crete, 4000, eastern Peloponnese, Attica, lowland areas of Eastern Sterea]
- Mountain: [Mountain areas with an altitude of about >1500m in northern Greece, >1800m in central Greece and >2000m in Crete]

Greece has a lot of sunshine almost all year round. In more detail in the various regions of Greece there is a wide variety of climatic types, always of course within the framework of the Mediterranean climate. This is due to the topographical configuration of the country which has large differences in altitude and land and sea rotation. Such climatic differences occur even in places that are a short distance from each other.

From a climatic point of view the year can be divided mainly into two seasons: the cold and rainy winter season that lasts from mid-October until the end of March and the warm and light season that lasts from April to October.

More specifically for Greece and for the long climate, we can identify, in accordance with the Thermal Insulation Regulation, three climatic zones.

Buildings located in zone A have greater needs for cooling and smaller ones for heating, in zone B they have about the same needs in cooling and heating and in zone C they have very small needs in cooling and very large in heating.

2. PATHETICS - SOLAR SYSTEMS

PATHETICS - SOLAR SYSTEMS

They are techniques that are included in the design of the building and are adapted appropriately to their shell. They facilitate the better exploitation of solar energy for heating buildings and the utilization of cool winds for their cooling.

Passive system applications

- Location - Orientation
- Sun protection
- Natural lighting
- Shading
- Natural ventilation
- Appropriate insulation
- Ecological materials
- Wooden constructions
- Planted soils
- High planting

COUNTRY - PERFORMANCE

Orientation is perhaps the most critical issue for creating an environmentally friendly building with low energy consumption.

The issue of orientation in general can be approached from two directions. Firstly as to how it places the building on the plot and secondly as to the choice of the plot itself.

For the orientation of the plot we can say that the more favorable it is, the better the energy efficiency of the building.

In plots with unfavorable orientation we can mitigate the impact on the building by the location of the functions inside, the configuration of the surrounding area and the appropriate architectural design of its shell.

For the placement of the building in the plot are identified two kinds of orientations the exterior and the interior.

The external orientation concerns the whole building; the building should be placed in such a way on the plot that the orientation of the various spaces is the most favourable for the use they are going to accommodate.

The internal orientation concerns the location of the uses – functions inside the building.

General principles

The placement of the school building on the plot must be based on the origin of the solar radiation.

For school buildings in particular, the placement of the building on the plot must be such as to allow classrooms to have good lighting throughout the year, the maximum solar gains from the impact of solar rays in the spaces during the winter and to ensure shading during the summer months, while ensuring the through ventilation of the spaces based on the prevailing winds in the area and inter-faceted lighting so that the to be adequately illuminated, to avoid the phenomenon of dazzle and to protect against noise nuisance by reducing the effect of external noise on classrooms.

Let us stress again here that while for Germany or Switzerland the "summer months" end no later than September, in southern Greece or Cyprus, with the climate conditions lasting until December.

Also the orientation of the plot and the building volume directly affects the planting. Plants must be selected and placed in the surrounding area on the basis of the exploitation of solar radiation.

Desired conditions

The most ideal guidelines for teaching spaces are considered to be:

The south, which offers ideal lighting conditions as long as the spaces are protected from direct sun and the north that offers stable conditions of indirect – diffuse lighting throughout the day.

Eastern and western orientations should be avoided.

When the ideal orientation cannot be achieved the spaces should be protected from the direct impact of the sun by other means.

Here we must stress that, as far as the southern orientation of the sites is concerned, many misunderstandings have occurred on the basis of the principles cultivated in northern and colder countries.

In addition, through orientation, classrooms should be protected from loud noises.

How to achieve

In order to achieve the desired orientation we must take into account the placement of the building in the plot. Where the conditions of the plot limit the choices of the scholar, the placement of the spaces inside the building should be chosen in such a way that the classrooms have the most favourable orientation, south or north.

It is also possible to achieve the desired orientation, at least in part, with the appropriate configuration of the structural shell. e.g. a classroom that has an exterior to the north and is located on the upper floor of the building is possible, with the appropriate configuration of the roof to receive sun from the south, and vice versa.

In general, therefore, it is desirable to orient the longitudinal axis of the building on the east-west axis, so that we can have the main openings of the sides in the south and north and avoid the east and west openings, where it is more difficult to handle the entry of sunlight inside the spaces.

The optimal orientation of the building creates the conditions for the use of sunlight, topography of the plot and vegetation, in order to increase thermal gains in winter and decrease in summer.

The sound protection of the spaces can be achieved by the correct orientation of the entire building or spaces within it.

Elements of the configuration of the surrounding area, such as solid walls and terraces and planting with trees and shrubs, can also be used.

In general, however, it can be said that knowledge of the solar orbit, the area, the soil, the vegetation and the microclimate are key factors in understanding the specificities of each plot in order to achieve the optimal orientation of the building and its spaces and to drastically reduce the impact of an unfavorable orientation.

SUN-PROTECTION

Proper sundling of buildings is one of the basic requirements of bioclimatic design. The use of solar energy through appropriate construction design can contribute, firstly, to ensuring acceptable indoor climatic conditions (visual and thermal comfort conditions), and secondly - through the proper thermal behaviour of the building - to limiting energy consumption, with all the benefits it entails (economically, environmentally due to a reduction in CO2emissions, quality oflife, etc.).

By suning it is achieved on the one hand to ensure thermal gains for the building during the winter season and on the other hand the natural lighting of the spaces throughout the year.

In the developing and supported European policy for buildings of better bioclimatic and energy efficiency, it is not considered appropriate in newly designed buildings to have gaps in the integrated management of thermal or light energy on the grounds of ex post correction of the situation with additional structures (e.g. pergolas, industrial standard shade, mechanically energy-intensive means, special crystals or membranes on crystals, etc.).

For this reason, the study team of a project, e.g. a school building, always at the stage of its initial composition, taking into account the orientations of the premises, their functionality, the geographical location of the building and any peculiarities of the microclimate of the area, decides and provides for the desired (in quantity and duration) reception in the space, or on the contrary, isolation from it, of direct solar radiation.

This can be achieved through the proper configuration and design of the exterior shell of the building, with the corresponding exploitation of the selected volumes, forms, structural systems and materials.

Solar orbit

In order to determine the sun rise of a building or plot we assume the apparent orbits of the sun, i.e. we consider that the earth remains stable while the sun moves. This assumption facilitates the geometric representation of the sun's apparent orbits, which follow a large continuous spiral.

The apparent orbits of the sun are identical every two months, except December 4 and June 17. The month of December has the lowest trajectory, while June has the highest.

In order to understand the effect of the sun on the design of buildings and sets, its position in the sky and the horizon must be known respectively.

This position is determined by the solid angle, which is broken down into two flat angles: the height angle defined by the position of the sun in the sky in relation to the horizontal plane and the angle of azimuth(angle yy), defined by the correct projection of the position of the sun on the horizontal plane, in relation to the actual direction of theSouth.

The determination of the sun is based on the correlation of the geometric data of the building with the geometric data of the position of the sun.

In other words, it is attempted, based on the apparent orbits of the sun, to determine controlled the sun of a space or building throughout the year.

Exploitation of solar energy for thermal gains

The buildings receive solar radiation, which passes mainly through the openings (windows) in the interiors and heats them. The most important element in the exploitation of solar energy for heating buildings in winter, but also to avoid overheating in summer, is the correct orientation of the openings. In order to make effective use of solar energy, there should be sufficient surface openings that can see the sun directly for several hours a day in winter.

It should be stressed here that the definition of summer or winter varies dramatically from region to region of Europe. The concept of cold winter with the need for maximum exploitation of sunshine in England or Germany applies from October when in Greece even in January temperatures reaching 20o.

Therefore, in southern regions of the Balkans, particularly with the already ongoing 20 climate change, the frivolous implementation of the directives on sunbathing sites drawn up by northern European countries can cause the regularly observed unviable, overheated environment of rooms south-oriented to Greek school buildings, usually without some sun protection.

For this reason, it is necessary to specify specifically in which

period of time it is desirable to enter sunlight into the premises of the building and to which it is preferable to control its entrance using appropriate means of shading.

Depending on the orientation of the openings, we should observe the following:

The southern openings ensure most hours of efficient suning of buildings during the winter season. According to what we saw in the previous paragraph, in winter the sun rises and sets south of the east and west; In summer the sun rises and sets north of the east and west, erases a long orbit, moves again to the side of the south, but high on the firmament.

It follows from the above that the buildings should be facing southwards in order to receive maximum sunlight deep inside during the winter. At the same time, however, this option allows for full shading with relatively small relatively horizontal protrusions during the summer months.

PHYSICAL LIGHT

One of the requirements in bioclimatic treatment in the design of buildings is to ensure adequate natural lighting and control of light radiation so that there is adequacy and smooth distribution of light within the spaces. A well-designed natural lighting system can drastically reduce the unnecessary use of artificial lighting during the day, thus saving a significant amount of the energy required for the lighting of the building (but also for air conditioning, as long as internal thermal loads are reduced) during its operation.

It has been observed that natural lighting affects human behavior in both direct and indirect ways: not only does it ensure the necessary light to see in the environment where one lives and works, but it creates a pleasant and human inner environment and also determines the cycle of day and seasons and at the biological level stimulates the hormones that regulate the body's systems and the mood of users.

The advantages of natural lighting translate into better performance of students in schools. Research carried out in the United States has shown that children achieve significantly better test performance in rooms that have natural lighting than those that do not, making natural lighting one of the most important parameters that the scholar deserves to invest in designing the school environment.

The design of natural lighting aims to exploit natural light in order to ensure adequate and appropriate lighting inside buildings in order to perform the functions that the building is intended to accommodate. The natural lighting of the building is achieved by designing the necessary openings on its enclosure, which allow the entry of natural light into its interiors.

Such openings can be created on the walls, roofs or ceilings of buildings and take the form of doors, windows, skylights, etc. consisting of transparent or translucent surfaces, such aslowlow-emissioneor low-emission glazing, glass bricks, polycarbonic sheets or other materials, depending on the function they are called upon to perform, the aesthetic choices of the scholar and the budget of theproject.

Direct solar and diffuse light

At this point it is necessary to point out the distinction between sunlight - which enters the premises of buildings especially when a complete study of openings has not been carried out - and the natural light that is desirable. In the international literature these two types of light meet sunlight as different and are described first as sunlight (direct sunlight), and the second as daylight (diffuse natural light).

Direct sunlight is too bright and too hot and therefore creates phenomena of glare and overheating of spaces. For this reason it is recommended to use only in places where users can move away from it, such as in traffic areas. On the contrary, in places where concentration and attention are required, it is appropriate to seek more gentle, uniform, diffuse lighting.

Visual comfort

Visual comfort within a space is characterized by three quantitative and qualitative characteristics, which must be basic criteria for controlling lighting in classrooms:

- The amount of lighting that reaches the working level.
- The distribution of lighting in the workplace (i.e. the uniform distribution of natural light in all desks).

Avoiding the blur that is usually created, either by the entry and impact of sunlight at the working level, or by the creation of intense photoskines in space. This phenomenon becomes particularly pronounced when the space has unprotected, in terms of shade, large openings on the southern sides of its spaces.

Basic principles of natural lighting design

In trying to define what the design of natural lighting means in a building we would say that it is the design that combines the following four elements:

- design the spaces in such a way that they use diffuse light from the sky
- use of natural lighting as a primary source of light in the premises of the building,
- use of various means and techniques to reduce blur
- design of electroluminescion as a complement to natural lighting.

The following principles can be a useful guide in the design of the natural lighting of schools.

Avoid the direct entry of solar rays into classrooms.

As already mentioned, solar rays are an extremely powerful source of light. Direct sunlight is so bright and warm that it can create intense visual and thermal discomfort to users of a space. For this reason, the design of natural lighting should aim to maximize the use of soft, diffuse natural light and to limit the direct entry of solar rays into classrooms.

One of the features of sunlight is that it changes during the day and from season to season. The daily and seasonal orbit of the sun is the main parameter for determining the availability of sunlight, while the presence of clouds and humidity in the air affect the quality and intensity of light from the sky. It is important for scholars to know the basic principles of sun orientation, climatic conditions and shading systems in order to successfully design the natural lighting of a building.

The orientation of a building is crucial to maximize the use of diffuse light and minimize direct solar penetration. With regard to the choice of the orientation of the building, it is generally recommended to place it along the north-south axis. This option has advantages in terms of the natural lighting of spaces located along the long sides of the building (north and south), since the north orientation gives the maximum diffuse light, and the south can be easily shaded throughout the year without hindering the view.

In this case the east and west side of the building do not have to have extensive openings. On the contrary, it would be a good idea to avoid as far as possible the orientation of buildings along the east-west axis and this is because the north and south edges of the building provide much less light inside than they could potentially offer, while the long sides (east and west) tend to introduce a lot of light and excessive heat.

Also, the east and west sides require complex shading systems, which often block the view.

Ensure soft, uniform light.

When the light is evenly distributed in the space, both the maximum possible energy savings and the desired visual comfort are ensured. Natural lighting can be used to provide a basic level of lighting throughout an area, ie diffused lighting. This is usually in the range of 220 to 330 lux. Artificial lighting can be used in areas where specific tasks are performed that require more intense lighting in the range of 550 to 660 lux.

Because classrooms usually have large openings on one side, heterogeneity is observed in the distribution of light. This can be achieved by skylights or even larger openings to the side of the corridor, or by openings on the roof of the hall or hallway on the top floor.

This can only be achieved in ground floor buildings or on the top floor of high-rise structures.

Walls, ceilings and other surfaces that can reflect light should be painted in white or light colors. Even pastel colors absorb 50% of the light that falls on them, reducing the amount of light reflected back into space. Bright colors are recommended to be used on smaller surfaces.

External shading elements or roofs located near the openings can have the ability to reflect natural light towards the interior of the spaces;

Lighting shelves can be used to direct natural light deeper into the space.

Avoid the dazzle phenomenon.

This phenomenon is caused when there are excessively high contrasts in surface lighting levels (direct glare) or when light is reflected on a shiny surface (reflection blur).

In cases where immediate dazzle occurs, the presence of a much brighter surface than the neighbouring surface, within the user's field of vision, causes annoyance or temporary loss of visual capacity.

This kind of dazzle has a negative impact on the performance of both students and teachers. Controlling the intensity of direct sunlight with elements such as provols, blinds, shadows, Venetian blinds or even curtains can help avoid dazzle.

Also the placement of light reflective surfaces near lighting openings (e.g. lighting shelves or the use of reflective surfaces on the ceilings of the rooms) helps to diffusion of light and smooth the contrasts in their lighting levels. The reduction of the contrast between the bright glass panes and the other interior surfaces of the space, makes them look more bright.

Generally the worst form of opening in terms of the phenomenon of dazzle is the opening that is not combined with any element of sun protection.

Design the electroluminescion system to complement natural light, and enhance energy savings through lighting control systems.

The design of artificial lighting must be done in conjunction with that of natural lighting, so as to complement each other and create overall high quality lighting. This requires an understanding of how each of these systems provide light in a space. The design of the electric lighting shall be such as to allow the lights to be switched off in the areas where the natural light is sufficient and to be switched on where it is incomplete.

The operation of this combination system can be checked manually or using automations (with photosensitive sensors that record light levels in space).

Other issues that the scholar should take into account when designing natural lighting are natural ventilation, visual communication, noise control, thermal comfort (hot and cold surfaces), student and building safety, air and water leaks, fire safety, cleaning, maintenance and the possibility of replacing some openings during the life of the building.

Types of lighting

The position, orientation and size of the lighting surfaces as well as the choice of their shading system are of great importance when designing the natural lighting of a space. Depending on the position of the openings in the housing of the buildings one could distinguish two types of lighting: the lighting from above and the lighting from the side.

Lighting from above [ceiling skylights]

Ceiling skylights, provided they are the appropriate size, are effective throughout the day, regardless of whether it is sunny or cloudy and regardless of the orientation of the building. Lighting from above can only be achieved in single-storey buildings or on the top floor of high-rise buildings. Ceiling openings allow uniform distribution of natural light in space and at the same time their use reduces the chances of the occurrence of dazzle phenomena.

Although in the international literature they are proposed as highly effective, in Greece the scholar must be extremely careful.

Ceiling openings should only be used as long as it has been ensured that they do not act aggravatingly for the thermal balance of the building, since in areas with intense and prolonged sunshine they are likely to contribute to the creation of a greenhouse effect within classrooms. In Greece roof skylights must have a vertical (and not horizontal or sloping) position and preferably turn to the north.

Lighting from the side [windows - skylights]

The most commonly used method of natural lighting is through lighting openings on one or more walls of the space.

Side lighting can be used on all floors of the building. Of course, the phenomenon of dazzle is not completely controllable without the use of shading systems and the penetration of light is not complete because the level of illumination drops sharply as the distance from the illuminating surface increases.

A simple and useful rule for calculating the useful light entering space from vertical openings is that the penetration of light equals about 1.5 to 2 times the height of the window preske.

This observation concludes that in order to achieve optimal lighting, the lighting openings on the walls must be as high as possible. [however, to ensure the view to the outside are necessary openings at eye level.

SHADING

A key element in ensuring the necessary comfort conditions within the buildings is the appropriate shading of the openings. It is worth noting, in particular, that, in warm countries such as Greece - especially in recent years where global warming has occurred - the design of solarism must be directly combined with the design of shading, in order to avoid - often observed in buildings in our country - global warming (greenhouse effect within buildings).

The reduction of solar thermal loads during the summer months and the limitation of the phenomenon of optical dazzle throughout the year through the shading of the openings, are essential elements for the restoration of thermal and visual comfort inside buildings.

During the summer months the shading of buildings is more effective when achieved before sunlight enters and is trapped through the glazing in the spaces, in which case the outer shader is preferred to the interior.

On the contrary, during the winter months shading is not desirable since with the sun of the buildings we can take advantage of the solar radiation for heating the interiors.

In order to determine the type of shading we can first refer to T.O.T.E.E 2423/86 (Table 203 Technical Directive T.E.E.) which specifies the appropriate air conditioning conditions for school buildings. For classrooms the optimum temperature is 18c in winter and 25C in summer.

Then, based on the climatic data of each region (meteorological stations E.M.Y.) we find the external temperatures (average, maximum, minimum) prevailing and determine for which periods we seek shading and which do not.

Using solar maps and simple mathematical calculations, the type of external shading to be selected can be precisely determined. Calculations can also be made through appropriate computer-based shading simulation programs.

Shading can be achieved with fixed external shaders (which can be building blocks, such as provols), with movable external shaders, internal shaders and a combination of external/internal shaders. As mentioned above, shading is most effective when done before sunlight enters and is trapped through the glazing in the spaces, so the outer shade is preferred to the interior.

At the same time, the use of movable shaders enables the openings to be shaded when necessary, i.e. when internal temperatures exceed comfort limits, regardless of the time of year and the position of the sun. Therefore, the most appropriate way to shade the openings is the use of external mobile shaders.

However, since external shadeboards with movable blinds are generally particularly expensive, it is alternatively suggested that fixed outer shading in combination with inner blinds. The external constant shading with the appropriate proportions ensures the elementary sun protection of the openings during the summer season and the sun during the winter, while the inner blinds complement its function when it is not sufficient, while also helping to avoid dazzle.

Mobile shader should stay low during hot periods and during non-operating hours.

Whenever a kind of lighting control, air heat attack or combination is planned, the possibility of visiting, cleaning and maintaining the exterior of the frames as well as the interior, to the building, of the appearance of the frames must always be calculated.

To calculate the shadow falling in the window from the proposed shading media, diagrams of the sun's orbit or appropriate software (e.g. " Solartool") can beused.

Different types of shading are recommended depending on the orientation of the aperture.

Shading of southern openings

In the case of openings facing south, it is appropriate to use horizontal shading elements. Thus, windows to the south can be shaded by a provol over the glass element.

In order to ensure maximum benefit from solar rays in winter - when they can make a useful contribution to thermal requirements - it makes sense to apply the probol in such a position that the rays can pass through the opening, when the sun is low in the sky, to the extent and months of time that will be considered beneficial rather than aggravating.

The calculation of the depth of the probosc should take into account not only its distance above the window, but also the height of the opening, its deviation and any deviation. The length of the probos toe is determined by the width of the window.

Shading of east and west openings

Windows facing east and west can benefit from vertical shading. Because the position of the sun changes, a mobile vertical flying can be the most effective way to ensure shading, although it can create stability and maintenance problems.

If a fixed toss is to be used, its dimensions should be determined by the width and height of the window and by the distance of the fly from it.

More specifically, we could refer to the following ways of shading.

Horizontal external fixed shade

Recommended for south orientation. Shadows may take the form of proboss or reflective shelves or blinds, with proportions such as to form between the outer shade and the apron of the opening an angle of 55 degrees for latitude 40 and 60 for latitude 36.

Vertical outer fixed shade

Recommended for east and west orientation. They may be vertical or inclined to the level of the opening floor plan. The length of the protrusion is determined by the angle of 55o for all latitudes of the country

External movable shade

These are generally metal blinds, horizontal for south orientation or vertical for east/west, driven, with manual or automatic adjustment mechanism.

Indoor Mobile Shade

They are recommended for southern, eastern and western orientations. The proposed solution for the operation of schools is Venetian blinds, preferably moving in guides, for reasons of good operation and longer life.

Shading from trees

In the east and west orientation very effective is shading, which is achieved with deciduous trees. However, it should also be noted the importance of vegetation for the creation of a favourable microclimate around school buildings, important both for achieving thermal comfort within the premises and for ensuring good and pleasant conditions in the ale.

NATURAL AIRING

Natural cooling is achieved by removing heat from the building by natural ventilation. Natural ventilation is achieved by:

- Through ventilation
- The phenomenon of attraction
- Old chimney
- Cooling Tower

Through ventilation

The basic principle of movement of wind flow within the shell with through ventilation is due to the different pressure distributions created around the building.

The inflow of wind into the building is made by the openings of the surface and exits the sub-surface and the roof.

In order to achieve better natural ventilation of the building by means of ventilation we could apply the following design principles:

- Installation of the building in the maximum direction of the dominant wind.
- Installation of air inlet openings in the windproof area and output openings in the windproof area.
- Provisions of greenery, windshields, architectural protrusions, side walls attached to the openings in order to create areas of positive and negative pressures favouring ventilation.
- Avoid placing obstacles at the entrance of the inlet and exit openings.
- The wind speed within the enclosed space changes in relation to the position of the openings. The prevailing tactic is for the air inlet and exit openings to be located on the opposite walls.
- The position of the input openings is more important than the position of the output openings. If the entrance openings are placed at a very high height there is the possibility that the air that will be introduced will be driven to the upper part of the space and overtake the people's pool.
- For small spaces where the air outlet openings cannot be placed on the opposite wall, we can place the opening in an adjacent position and create a kind of natural ventilation (this application is done in very small spaces).
- When planning the natural ventilation of the building it is good to take into account the conditions prevailing during the night hours in order to take advantage of the natural ventilation during these hours.
- Openings must be easily accessible to tenants.
- The input surface and output surface shall be equal. High speeds within the enclosed space can be achieved by increasing the output opening surface by 25% relative to the input surface openings.
- It is important to avoid openings being at the same level and opposite.
- Horizontal wells and layouts can drive air inside the space at some speed.
- We must take into account topography, local architecture in order to redirect the flow of wind and create the appropriate conditions for exposure to local winds in the area.

Natural attraction

The temperature difference between the hot air inside the building and the cold air on the outside cause the accumulation of hot air at the highest point of the room and its exit from the ceiling.

The air heated by internal thermal loads (people, lights, heating) expands and rises. The movement of the air creates a gradient of pressure and its rise upwards. The openings of the building make the phenomenon of natural attraction more pronounced.

The weight of the air depends on temperature and density (cold air is heavier than hot air in the same conditions).

The phenomenon of attraction applies mainly during the winter months, where the temperature difference is the greatest.

During the summer months the phenomenon of ulceration does not apply because it requires the internal temperature to be higher than the external temperature, which is impossible during the summer months. During the night hours of summer, however, ventilation is very important and helps to discharge the heat that has accumulated in the building during the hours of the day.

In order to achieve better natural ventilation of the building with traction we could apply the following design principles:

- If the inlet and output openings have an equal area, a balanced and maximum ventilation of the space shall be created.
- The width-height ratio of the openings must be greater than 1 (the openings must be placed horizontally).
- The minimum vertical distance between the inlet and exit openings in order to create the chimney effect is 1,5m.
- Vertical wells and open stairwells can be used to increase the chimney effect.
- The openings must be used correctly depending on the temperatures of the indoor and outdoor environments
- Any mechanism at the entrance and exit must be kept in good condition and clean in order to maintain hygienic conditions.
- During the design of the building, account must be taken of the proper operation of the natural ventilation with the artificial air conditioning of the space.
- The openings causing natural ventilation must remain closed when the mechanical air conditioning mode is in operation.
- Air inlet openings must not be placed in parking lots.

Solar chimney

The solar chimney has similar basic operating principles to the phenomenon of attraction (Venturieffect) thus enhances ventilation in the interiorsof the building.

The solar chimney is made of glazing on the south or southwest side of the building.

The in chimney trapped air is overheated (relative to the inner air of the building) by trapping the solar rays through the glazing and is driven from the chimney to the planned top, creating pressure lower. The solar chimney finds application during the summer months. Warm air escapes from the top of the chimney and is replaced by air inlet openings with fresh air.

- Recommended in areas with high humidity.
- During the winter months the hot air produced in the solar chimney, can with an appropriate fan device be driven into the building and used to heat the space.

Ventilation chimney (Cooling Tower)

The cooling tower is an element of the building that uses wind dynamics. The shape of the tower is usually square, rectangular, or triangular. It is placed on the roof of the building or next door, as a separate construction.

In order to achieve better natural ventilation of the building with cooling tower we could apply the following design principles:

- Sides of the cooling tower are usually 3m wide and the height is 7m
- The last part of the cooling tower is open from all sides in all directions of the wind. Thus there the wind flow is trapped and a median channel leads the outside air to the interiors of the building.
- At the same time, it could also be used as a chimney. Thus, when there are no local winds the space can be ventilated with the phenomenon of attraction.

In the following table there is a concentration of the principles of ventilation operation with the phenomenon of chimney and through ventilation. Proposals are also presented on how both methods could be combined.

INSULATION

The importance of thermal comfort in our daily environment is great. Especially in schools the existence of thermal comfort has to do with the performance of students and teachers and thus their proper functioning.

Each building is a shell through which amounts of heat can pass from the inside to the outside or vice versa. The transfer of heat through the shell is a complex and multifaceted phenomenon. The direction and size of the heat flow is affected by the solar impact and the external and internal temperature. One of the factors we need to take into account in the design in order to achieve maximum thermal comfort with minimal energy expenditure is insulation.

Thermal insulation of a space can be achieved in a direct or indirect way. When we say direct means the use of thermal insulation materials in construction, whether they are provided for by design or added in retrospect.

Direct insulation of existing buildings can be achieved by:

External thermal insulation

It will be made from non-hydrophilic materials as thick as required by the study and will surround all structural bearing elements as well as brick walls, substrates and concrete beams. The other solution in the case of interventions in existing buildings, where the installation of external insulation may be considered unprofitable, is the installation of a layer of thermosova that will contribute to some extent to the limitation of thermal losses.

When it comes to protecting the interior from higher ambient temperatures then the internal insulation performs better because it avoids the thermal accumulation of the outer casing for the benefit of both the interior and the immediate external environment where this energy will be attributed at night.

The thermal insulation of the exterior masonry brings energy savings annually to 42% for the A climate zone, 24% for zone B and 17% for zone C.

Internal thermal insulation

It is recommended where external thermal insulation is not possible or easy. The thermal insulation of the interior masonry contributes to energy savings annually at 57% for the A climate zone, 38% for B and 27% for C.

Performance

Internal insulation gives higher rates of energy savings, but can contribute to condensation of water vapor inside the walls. Moreover, external insulation is a more complete solution because it protects the outer casing from weather changes, but also because it ensures less variation in internal temperatures and greater thermal comfort during the warm season.

The solution of intermediate thermal insulation between two sets of bricks, which is usually applied is also possible. This type of thermal insulation, of course, if not taken care of, leaves a number of thermal bridges in the concrete elements (e.g. support, beams, slabs, pretzels, etc.).

Ceiling insulation

External insulation

There is the classic thermal insulation of rooms (or roofs) placed under the sealing layer and, usually, over a thin vapor barrier to avoid condensation within its mass.

However, there is also the "inverted" thermal insulation which is placed (mainly on the roofs) above the sealing layer, therefore it must not be damaged by wetting and is usually protected from above with materials resistant to ultraviolet radiation and with resistance to sub-grabbing (e.g. layer of man-made or natural stone slabs in dry position or layer of appropriate thickness of visible brittle material).

Materials that can be used for the rooms must be impervious to water (non-hydrophils). The thickness of the thermal insulation layer for zone C can be 5 - 7 cm. whereas for zones B and A the thickness of 5 cm. is sufficient.

Internal insulation

Thermal insulation from the inside of a floor (or even from a slope of slabs) of reinforced concrete should in any case be avoided. It creates strong marks on the roof due to differentiation of condensations in the joints.

It also allows thermal cumulation on the floor plate and transport of the thermal load overnight via any thermal bridges inside, while at the same time burdening the immediate external environment by expelling the concentrated on the day of the load.

If the roof under its prismatic formation does not have a horizontal roof (ceiling) then again it is preferable to place the thermal insulation above the skin and the associated water vapor barrier and under the sealing layer. Various kinds of tiles are no longer considered adequate waterproofing and require such a layer just below.

If there is a ceiling then the thermal insulation can be placed within the prismatic space of the roof considered as an intermediate thermo chamber.

In both cases (external and internal insulation) the energy savings are of the same order. The external insulation, however, due to the maintenance of thermal mass inside the building, contributes to thermal comfort in the summer.

At the same time, it is recommended because it protects construction from disasters due to large fluctuations in temperature over time, and, as mentioned, does not burden the environment.

Performance

From a purely energy point of view and due to the large losses from ventilation but also due to the relatively small surface area of the roof, the efficiency of the roof insulation is small, amounting to 8% for the A climate zone, 7% for the B climate zone and 5% for the C. From a thermal point of view, however, the insulation of the roof intensifies the feeling of thermal comfort in the rooms of the top floor, both during the winter, but especially during the summer, where no mechanical cooling/air conditioning system is provided.

Another way to insulate the roof is the creation of planted rooms, but construction in Greece is relatively difficult to do and maintain successfully.

The choice of the material of the frames plays an important role in the building insulation. Steel, for example, is a material that is more heat-permeable than wood but less than aluminium (although more expensive), while glazing can also be double (in zones B and C or on north-facing faces).

Insulation of course is a factor that must be taken seriously from the beginning in the design of a building.

The capacity of heat absorption from materials and its performance in the environment (external or internal) varies. Characteristics refer to the thermopermeabilitys of wood, glass and concrete.

In practice insulating materials age without knowing precisely the aging mechanisms The sure thing is that there is a continuous change in the initial balance of their solid and gaseous components so the thermal conductivity factor l always increases.

Indirect insulation

In addition to direct insulation modes, a shell can also be insulated in an indirect way, i.e. with structural systems such as double floors with vacuum, double walls with vacuum, lining of the sides with a wood mesh that creates a microclimate between the existing face and the lining.

This system allows for shading of the face and the existence of a gap of 5 cm. between the old face and the new skin of the building. This vacuum allows air circulation and therefore the natural indirect insulation of the building, reducing to a minimum the surface of the face with direct solar impact (see indicative sketch).

Another system for indirect building insulation is the insertion of empty outdoor or semi-outdoor spaces between the units of the building, in order to reduce the thermal amounts transferred from one space to another.

Ecological insulation materials

A material is called an insulating material when it meets the following criteria:

- It doesn't require much energy to produce it.
- It does not contaminate the environment during its production.
- It does not contain toxic or carcinogenic pollutants.
- Hazardous materials according to the InternationalIARCCancer Research Centre (IARC) are polystyrene, glass wool, stone wool andpolyurethane.
- It's recyclable.

The most important ecological insulation materials are flax (produced from flax), cotton residue roll (ISOCOTTON type) and expanded cork. These materials are environmentally friendly if recyclable and with the exception of inflated cork cost little; natural cork comes from the bark of cork trees grown in Portugal, Spain, Algeria etc. Today Portugal produces70% of the needs of the European Union.

Waterproofing

Waterproofing is of great indirect importance for the bioclimatic function of the building because its non-existence can neutralize the thermal insulation capacity of certain materials used in thermal insulation. This fact is easily explained when you consider that the thermal conductivity factor of water is 0.57 WW/mm. K while the still dry air is 0.024 W/mm. W K that is, he's four times smaller.

The most important material affected by moisture is glass wool which being highly hydrophilic can easily be completely neutralized as a thermal insulation layer. In contrast, other thermal insulation materials such as stone wool or high-density axed polystyrene show significant resistance to moisture intake.

However, proper sealing membrane and careful water vapor barrier combined with ventilation capabilities, in correct positional choices in terms of thermal insulation layer is the best guarantee for their high and long-lasting performance.

Also the humidity in a space increases the cold in it, while the increase in water vapor and condensations is contrary to the thermal comfort inside.

LOW COST MATERIALS

The choice of building materials is related to the sustainable or non-sustainable dimension of constructions, since the use of building materials that do not meet environmentally friendly criteria can result in:

- Waste of natural resources and energy
- Disruption of the environment from extraction – scraping of raw materials, production, transport and use of building materials
- Effects on people's health
- Deterioration of the microclimate around the building

For certain building materials a label is provided, which gives the consumer certain guarantees for the environmental solvency of the product.

Such marking may be given either by national and discretionary bodies or by independent non-governmental bodies.

For building materials that do not have any eco-labelling, a methodology has been followed in recent years in many European countries. In other words, it is recommended to use some materials and it is recommended to avoid others.

WOOD CONSTRUCTIONS

Today, a variety of composition of space covers with all structural systems and materials is applied worldwide.

The choice of wood has the following advantages:

- Aesthetics, wood has natural beauty and warmth
- Good seismic behavior
- Lightness of construction

PLANTED ROOMS

Planted soils are an indirect way to restore vegetation to the built environment.

Planted roofs are a means of thermal insulation of the building.

In summer, solar radiation is prevented from reaching the building shell through the shadow created by the plants on the surface of the roof. That is to say, the effect of the solar radiation on the roof of the building, which is an important source of thermal burden on the building, is zeroed. Finally, the plants contribute by evaporation from their leaves, to the evaporative cooling of the roof (evaporation).

In general, planted rooms contribute to the creation of mild conditions in the spaces above which they are placed.

However, the design of a planted floor requires special attention, because it is variously connected to the building and has various effects on it.

Necessary conditions :

- The bearing structure has been calculated to carry the loads of the garden
- Appropriate insulation of the floor (waterproofing - thermal insulation)
- Separation of the insulation of the floor from the construction of the garden to protect it from the chemical and mechanical effects of the garden and especially from the penetration of the roots of the plants.
- Selection of plants capable of growing in the special conditions prevailing in the soils (climate, soil)
- Irrigation of the planted soil and rainwater runoff.

HIGH PLANT

Landscape Architecture takes care of the exploitation of the functional properties of plants in order to substantially improve the exterior spaces both aesthetically and functionally.

Depending on the aesthetics and function of a space, the appropriate configuration and planting of selected plants takes place.

In order to limit direct sunlight as well as reflection in a building, we place plants of appropriate height.

Evergreen trees should be used on the north side of buildings or where they alter the local flow of winds and protect the zone from cold winds.

In Mediterranean climates and at latitudes below 40, the western side is ideal for planting evergreen trees.

The plants selected must be more than 1,80m tall and vary in colour and size to avoid monotony.

Vegetation either as a grass surface or as a tree foliage significantly increases the reflection of the resulting solar radiation, on the contrary asphalt, concrete or other dark surfaces, reduce reflection and increase absorption.

3. HYBRIDIC SYSTEMS

They are passive systems that also use mechanical means whose operation requires conventional energy, much less than the hybrid system itself saves.

SUN CHIMNEY WITH ANEMISER

It is a chimney through which natural lighting is transferred to the underlying floors of the building as well as the natural ventilation is accelerated.

In warm climates fans are used to move air masses and create a sense of comfort in people by increasing the evaporation of moisture from their bodies.

As long as there is air movement, people in space can withstand higher temperatures.

The air movement caused by the fan differs from its position, engine power, the size of its wing, and the number of fans in the room. Also the speed of the air differs from the distance of the fan from the man.

The average fan power ranges from 15 W to 115 W for high speeds; they find application in spaces of different uses, including offices and classrooms; they can be used in almost all areas that require cooling; the combination of natural ventilation and fan could completely eliminate the need for air conditioning.

Fans do not find application in case we do not want to have air movement or apply the chimney effect.

In order to achieve better natural ventilation with fans we could apply the following design principles:

- Fans must be used in places where there is human activity and only during it. The engine's movement produces heat without any cooling benefit. Fan movement creates cooling conditions for people and not for space.

- The use of fans with large fins increases airflow on larger surfaces, at lower speeds and with less noise.
- The fans work more efficiently when the fins are about 2.5 m above the floor, and m 3.5 m below the roof.
- The fan selected must have a minimum of 2-speed for better air movement adjustment.

4. ENERGY SYSTEMS

It is those systems that use mechanical means for heating or cooling buildings, utilizing solar energy or natural cooling tanks.

Applications of energy systems

- Photovoltaic systems
- Ventilation of classrooms with CO2 sensors
- Automatic electrical installation control system (smart buildings)

PHOTOVOLTAIC SYSTEMS

The use of photovoltaic systems aims to:

- Reducing energy produced at national level from fossil fuels
- To the significant environmental benefits, by limiting the emissions of
- In the most economical energy production

The advantages of this system:

- Environmentally friendly technology as long as no pollutants are caused by energy production
- Solar energy is decentralised fuel, available everywhere and does not cost
- Silent mode
- Almost zero maintenance requirements
- Long life (25 years)
- Possibility of future expansion to meet the growing needs of users
- They can be installed on existing structures
- Flexibility in applications, if they function perfectly, both as autonomous systems and as

hybrid systems, when combined with other energy sources (conventional or renewable) and accumulators for the storage of the energy produced.

It is estimated that the cost of building a photovoltaic system has been depreciated in 10 years, when its total lifespan is 25 years.

D3. AUTOMATIC ELECTRIC INSTALLATION CONTROL SYSTEM (EXPENDITURE BUILDINGS)

It is known that in school buildings 70% of the energy is consumed for heating and 30% for lighting. Through a special system that takes into account existing solar lighting, as well as whether or not there are students in classrooms, lighting through lamps will be reduced or not used.

It is an electronic system of energy and environmental management of buildings, which on the one hand will provide the best possible environmental conditions – taking into account the technical specifications and specificities of each building and on the other hand will save energy from heating, cooling, ventilation and lighting units.

'Smart buildings' propose the installation of automated mechanisms to ensure that building users have the best possible environmental conditions in terms of thermal comfort, lighting and indoor air quality, with the minimum possible energy consumption. These mechanisms will be adapted to the specific characteristics and requirements of each building, while being integrated with modern electronic management software. The system will also be able to assess the energy and environmental performance of the building and propose methods of improving it.

This system responds to the wider European Union's environmental protection policy, through rational design and building management, as well as to a specific Directive which pushes Member States to adopt stricter standards for the energy efficiency of buildings.

5. RENEVABLE ENERGY

RENEVABLE ENERGY GUIDES

It is the natural resources available that exist in abundance in our natural environment, that are not exhausted but are constantly renewed and that can be converted into solar thermal energy, such as sun, wind, biomass, geothermal, waterfalls.

Applications

- Geothermal
- Rainwater management (tanks)
- Adjustable water flow time valves

GEOTHERMIA

Geothermal energy is a form of mild renewable energy. It is stored energy in the form of heat, under the fixed surface of the earth.

The temperature of the subsoil at depths from 2.00 to 1.00m,is about constant all year round and ranges from14 to 18C for our country.

The temperature difference between the subsoil and the surface is exploited using geothermal pumps and a network of pipes within the subsoil, so that we can heat the spaces in winter and cool them in the summer.

Geothermal energy is available all year round, not dependent on the weather conditions of the atmosphere.

This energy is exploited by two systems:

- closed-circuit geothermal systems
- open-circuit geothermal systems.

Closed-circuit geothermal systems are based on the construction of an underground alternator (geo alternator), which is constructed from a number of pipes in which water circulates.

In winter, the geothermal heat pump is fed with water at a temperature of about 16oC by the geo alternator, which absorbs 4–5C before returning it to earth.

Thus with low electricity consumption, hot water is produced 35–45 c suitable for heating C (underfloor, fan coil))

The geo alternator can be placed in a horizontal or vertical arrangement. The horizontal layout shall be used when the surface of the plot is sufficient.

Open-circuit geothermal systems pump water from an underground reservoir using drilling and using an intermediate water exchanger inserted between the geothermal heat pump and the open circuit, give or absorb energy to our system before the water returns to the reservoir. This system is suitable in areas with a low depth of aquifer.

The pipes must be transported underground in order to avoid energy losses during the introduction into the building.

MANAGEMENT OF OMBRIAN WATERS

It is a water collection system in a reservoir, which is available for irrigation of the air space, as well as for the W basin supply network.. C.

WATER REGULATED TIME BALVES

They are placed in courtyard faucets, sinks as well as urinals and sanitary basins.

With this installation there is water savings because there are no losses from poor and reckless use.

IMPLEMENTATION OF BASIC BIOCLIMATIC AUTHORITIES IN SCHOOL BUILDINGS, REQUIREMENTS AND NEWS

New education buildings

As already mentioned, proper bioclimatic design requires the right design choices of the building, already from the early stages of architectural composition. Options starting from the appropriate selection of the plot, the most favorable placement of the building in it with the best possible orientation, the design of the form and structure that will allow maximum energy gains and will minimize the need for additional elements that will ensure the proper functioning of the building.

This need for proper, bioclimatic design in the first place has already been accepted in the context of school building design. New studies take into account bioclimatic principles and new schools tend to take advantage of natural lighting and ventilation to the greatest extent possible. However, further training of architects initially, and of mechanical and civil engineers thereafter, while developing a spirit of cooperation towards this goal, is considered necessary.

The coherent bioclimatic view of the bioclimatic school, with the existing climatic conditions and the modern energy problem is now becoming imperative.

Existing training buildings

A serious issue remains how we can manage and improve existing school buildings. Due to the fact that special recording and measurement studies have been carried out, we have the possibility of forming more computers where criteria of age, building mode, possibilities of intervention are involved. For example, we give the typologies as they will ultimately guide the selection of appropriate interventions.

There are 3 categories of existing schools:

Category 1: Buildings up to 50

Neoclassical, stone, or interwar with thick masonry, compact.

Constructions of stone or brick with belt, concrete slabs, concrete roofs or even wooden, without insulation. Their frames are metal (iron) with poor fit and single glazing.

Category 2: Buildings from the '50s to '80s

Reduces the thickness of the walls. Iron frames. Insulation absent, roofs without insulation. Special category are the schools of MOMA, prefabricated, with great thermal inertia (concrete elements

50 cm thick).

In categories 1 and 2 there is usually a linear layout where on one side is the corridor and on the other the rooms are lined up. A lot of times the hallways are open-air. School hours are mostly breakfast. Gradually the afternoon shift is completely abolished. Thus, while thermal comfort is required in the morning only hours, it is important to maintain the heat in the building during the night until the early hours. This means that a great deal of thermal inertia must be ensured in the building, i.e. a large mass in the shell.

Possible interventions in categories 1 and 2:

- Closure of outdoor corridors that will play either a halt or a thermal profit-raising role
- Masonry insulation. Priority in schools between 1950 and 1980 with thin walls. In the rest the thickness of the walls delays the losses, so the main escape route of thermal loads is their roof. The external insulation of masonry in these schools will have particularly positive results because they have large heat stores, but there is always the question of the high cost of such an intervention.
- Roof insulation. The thermal load reduction is indicatively shown as follows: For zone C: 14%, for zone B: 4.5%, and for zone A: 14%
- Replacing frames. In this case the reduction of thermal load is: For zone C: 7%, for zone B: 4% and for zone A: 6%
- Add passive solar systems. Where the corridors are south they can be converted into solar spaces along their entire length, or intermittently in combination with widest (stop areas at the break). In this case, the following figure is presented for the reduction of thermal loads: For zone C: 28%, for zone B: 8.4%
- Where the rooms are south, because the frames usually occupy the entire length of their exterior side, it is not possible to apply solar walls (small height). However, solar spaces or water heaters can be added, through which the air of the required ventilation of the rooms (5 times/hour) is preheated. Data to reduce the thermal load in relation to the panel are not available.
- Cooling by ventilation, where : The reduction of thermal load for zone B: 63% - 81%, for zone C: 55% - 79%
- Shade, where: The thermal load reduction for zone B is 20% and for zone A ranges between 12% - 37%.

In these categories, the high probability of non-suitability of the skeleton from reinforced concrete should also be observed and taken seriously. This combined the well-known process of weakening this by carbonation and oxidation of its armament with the fact that it was studied with (mainly seismic) assumptions, very different from the current acceptable limits.

The usual prefabricated reinforcements of the reinforced concrete frame again with the addition of thinner elements of the same building material, except that they can falsify any aesthetic value, are short-lived and have very high costs.

Category 3: Buildings after '80s

This is where the school buildings built after the Thermal Insulation Regulation belong. These buildings present the following problems:

Thermal insulation (mainly polyurethane and styrofoam) covers only up to 30% of the shell. The rest of its surface either creates thermal bridges (all plates, beams, divorces, substrates and protective roofs of the frames are not insulated and make up the largest percentage of the solid elements of the shell), or is covered by frames.

Transparent surfaces are very large and particularly aggravating if they face north.

Precisely because transparent surfaces have grown to an extent but usually without any shading protection, nor with careful orientation selection but, above all, with morphological (or even morphocratic) design selection criteria, there is a great problem of overlighting and, above all, overheating, even on, increasingly presented, sunny winter days.

Interventions in existing schools require a specific study to take account of the new requirements.

The school halls, according to the specifications of the O.S.K., need frequent ventilation. It is important that their heating is mainly based on the radiation of the building blocks and not so much on the heating of the air, which rotates very often.

It is also necessary to study methods of warming up fresh air entering the halls. The above elements are proposed subject to favourable (southern) orientation.

The interventions mentioned are workable in existing schools because, on the one hand, they are relatively standardised in relation to public office buildings or other public utility buildings and, on the other hand, because they are more appropriate interventions, since they are usually found in free land. The problem of school housing tends to be covered very soon and in the future we will have a small percentage of newly-re-involved school buildings.

6. ANNEX 1: DIRECTIVE (EU) 2018844