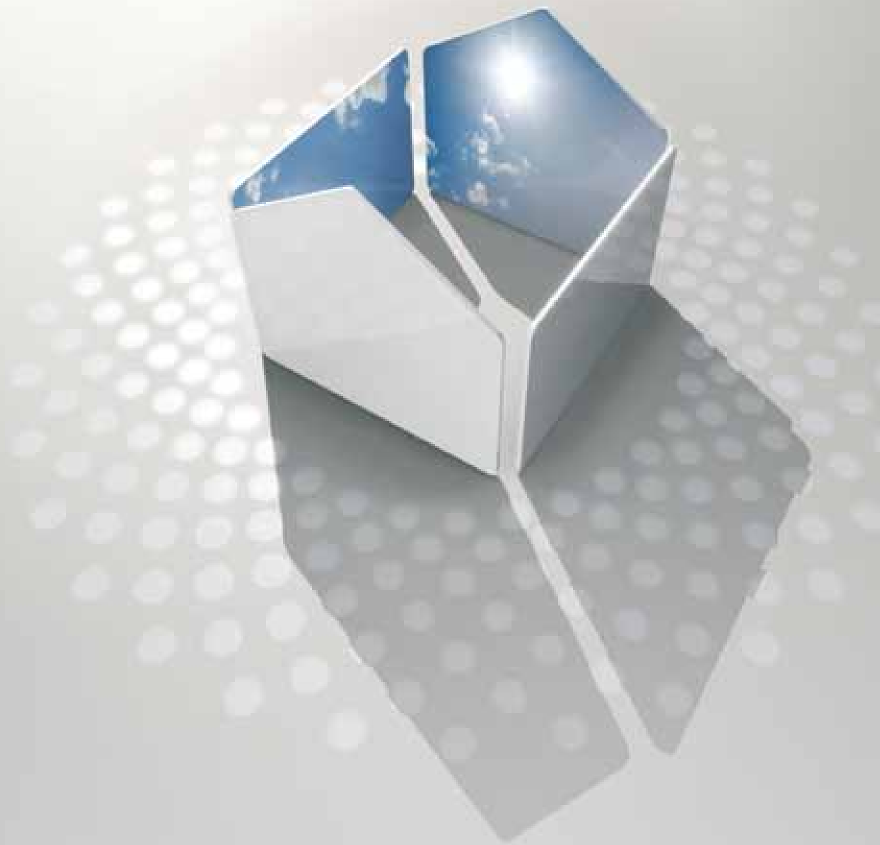
TEENERGY SCHOOL. GUIDELINES

Teenergy Schools

high energy-efficient
architecture for secondary
school-buildings
in the Mediterranean area



GUIDELINES

Selection and design of the site

Materials and construction technologies

Renewable energy

Control System for energy saving

TEENERGY
SCHOOLS

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Selection and design of the site
Noise pollution decrease

Pic. 01 - Kindergarten school in Ponzano. The wall insulation helps to increase the well-being indoor in order to reduce noise and to save on energy costs.

Description of the strategy

One of the most neglected aspects in the design and construction of schools is the acoustic quality of internal and external environments. This is a necessary condition to ensure the proper way of teaching and the psychological well-being of teachers and students. Among the negative effects produced by a low level of isolation from external noise, there is the phenomenon of "masking / distortion" of the word resulting in a lower level of concentration among pupils. The reverberation time in classrooms affects the tone of the teacher's voice (strength and rhythm), making difficult the job of the teacher and the listening. The quality of the acoustic evaluation of the school depends on many factors: the environmental and urban area characteristic, the dimensional and morphological aspects of the building and outdoor environments, material, position of furniture and fixtures. Other factors may be subjective, as the age, the typology of users their activities etc.
The main sources of noise can be as follows:

- Atmospheric phenomena like rain, wind and hail.
- Traffic due to its proximity to densely urbanized areas.
- The presence of terminal plants and machinery.
- The presence of internal ventilation ducts not properly insulated.
- The presence of old heat distribution networks.
- The presence of not compartmentalized internal open spaces.

Many existing school buildings constructed in the period, prior the adoption of the Ministerial Decree - December 18, 1975, although they don't highlight any particular and specific technological solutions for soundproofing, they don't show problems related to aircraft and foot-traffic noise, being characterized by a bigger mass of the building elements that generally respond best to sound waves than the techniques that use light elements. However, most of the existing school buildings have values of the levels of reverb and isolation that exceed those established by the Ministerial Decree - December 18, 1975. Many of these buildings are located in densely urbanized and busy areas and they must restrict the opening of the windows. In this way it's difficult to ensure the optimal number of air changes within the classrooms.

Notes

The Ministerial Decree "December 18,1975" analyzes the requirements for sound insulation transmitted by air and foot traffic, requires the values of the reverberation time of the premises and determines the limits of the level of noise emitted by plants. It doesn't give any indications on the insulation of the external noise and doesn't mention the performance of doors that are critical components for a good sound insulation of walls.

Target - Mediterranean area

The strategies used to improve the acoustic comfort of the school buildings are:
- A relevant insulation of pipes and/or air ducts
- The reduction of reverberation time in classrooms using sound absorbing materials for structures and furniture.
- The acoustic isolation from external noise from other rooms through proper design of sound insulation of partitions such as walls, external walls and floors, and the use of sound-proof windows and doors.
- The reduction of "acoustic bridges" generated by discontinuities in the structures.

In addition to the technical devices also the functional distribution has a determinant role, for example it is very important to place the classrooms in relation to the common and distribution areas, creating in a suitable way the size and the morphology of the environments.

Norm Reference

Ministerial Decree - December 18, 1975 - Updated technical standards for school buildings, including the indexes of educational function, construction and urban planning to be observed in the works of school buildings.

Pay back period

Medium

Estimate of achievable saving

20-30 %

Environmental quality degree of improvement

1	2	3	4	5

01.01
Noise pollution decrease

Pic. 02 - Elementary school canteen "Cesare Battisti", Fiume Veneto Pordenone. There are acoustic circular elements with a diameter between 1.2m and 1.85m. detached from the ceiling in order to optimize the sound absorption on both faces of the elements.

✶ Closer Analysis

The strategies adopted to improve the acoustic comfort are the following:
1. The correction of time reverberation of the internal surfaces through the use of sound absorbing materials, also chosen for the duration, the combustibility, the wash ability, the mechanical strength, the aesthetics and the sound absorption coefficient (between 125 and 4,000 Hz). In the design of classrooms and laboratories it should be noted that large areas expand the sound, while small surfaces (i.e. size comparable with the wavelength of the signal tend to disperse the sound) and/or equipped with irregularities exceeding ¼ of the wavelength of the signal tend to disperse the sound
2. Reduction of noise transmitted through the doors by using multi-layer materials for the construction of the fixtures and the removal of all unnecessary openings. Any type of opening has to be avoided by using double or triple seals in the edges, and special joints placed in contact with the floor. The seals should be made of plastic foam or rubber in order to avoid the creation of the excessive resistance to the closing of the door.
3. Reduction of noise transmitted through pipes and air ducts using open-cell insulation materials and sleeves, or creating mazes of acoustic absorbing sound waves. In order to avoid the noise coming from the outside, it is necessary to also adopt sound-absorbing elements within the devices and intake air, particularly if installed in closures.
4. Realization of a sound-absorbing ceiling, able to contain the sound energy absorption for the environment (related to the porosity of the material), for resonance (related to the stiffness of the panel) and for resonance of the cavity (due to the drilling of the panels and the volume inter space). Aluminum panels, PVC, plaster, glass wool with visible treated surface or mineral fibers can be used. The panels must be suspended from the ceiling by tie rods of metal or rigid brackets adjustable with screws or by interposed spring. In this way, avoiding the connection between the ceiling and false ceiling, it is possible to eliminate any transmission of noise due to structural reasons. It is important to design properly even the distance between false ceiling and intrados floor since the increase of the distance causes the downward displacement of the frequency resonance of the panel-cavity system which creates an increase of the absorption of low frequencies.
5. Appropriate choice of the site where to build the school: the decree indicates to realize schools in specially protected areas characterized by daytime noise levels below 50 db. Even the shape of the building and deployment of space should be designed and evaluated based on external sources of noise.
6. The use of windows that guarantees the isolation of noise outside. It is better to use laminated glass and frames to ensure the sound isolating frame-glass and frame-counter. The acoustic decoupling can be obtained by inserting gaskets to solve the laying tolerances both between the chassis and that between two glass panes in the case of double glazing: this strategy ensures the air seal and prevents the transmission of vibrations. The roller blinds must also be soundproofed by wind brushes.
Finally, it is better to choose fixed ventilated machines able to ensure the exchange of air without the need of manually opening windows.

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Selection and design of the site
Orientation and morphological formal choices

Pic. 03 - South Facade, Majorana Secondary School in Capannari, Lucca. Project: Lucca Administration, 2011

Description of the strategy

Both in the case of new construction or redevelopment, the decisions for the energy efficiency of a school building have to be taken when you start planning, because, even at this stage, the minimum standards set by the law must be respected. Special attention to the environmental assessment of the site chosen and a proper study of the shape and orientation of buildings are crucial to optimize the energy efficiency, achieved through the proper exploitation of solar radiation and natural ventilation in order to ensure good comfort conditions for future users. The design of a building and its location, in fact, has a strong influence on its thermal behavior, in winter and in summer, because with a change of shape and orientation vary the exposure to solar radiation and the exposure to prevailing winds.

Notes

A proper design can not be separated from the analysis of the geographical climate in which the complex architecture fits. A study of the characteristics of the location (latitude, longitude and altitude) and its special climate is necessary to identify strategies to ensure a bio-climatic comfort conditions throughout the year.

Target - Mediterranean area

In the Mediterranean countries, the analysis of climatic data is essential to offer distribution plan metric solutions of the building and its interior and appropriate technological systems to ensure a comfortable indoor situation both in winter and in summer, helping to reduce the energy requirements for conditioning throughout the year.
During the initial stage of the project it is important:
To find the climatic data of the project area using national or international databases.
To analyze the microclimate of the area where the building will be located, with particular attention to the elements that can create favorable conditions to its air conditioning systems (lakes, vegetation, man-made screens) and to the environmental elements with a negative impact (obstruction to solar radiation, industrial settlements, urban traffic infrastructures).
To provide a climatic map which highlights the solar diagram, wind direction prevailing elements with negative or positive environmental impact.

Norm Reference

Ministerial Decree - December 18, 1975 - Updated technical standards for school buildings, including the indexes of educational function, construction and urban planning to be observed in the works of school buildings.

Pay back period
Medium - Long

Estimate of achievable saving
Energy saving on of the entire building envelope

Environmental quality degree of improvement

1	2	3	4	5

01.02
Orientation and morphological formal choices

Pic. 04 - North Facade, Majorana Secondary School in Capannari, Lucca. Project: Lucca Administration, 2011

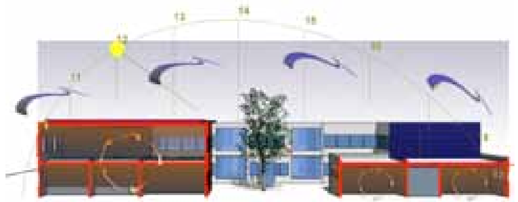
✶ Closer Analysis

Even the design of school buildings is not possible without a careful analysis of the project site and microclimatic conditions. It's always a good idea to build an environmental charter of the site to outline the main climatic elements that can be used to contribute to the users comfort and reduce energy requirements for heating and cooling. It's important to highlight:
- Orientation with north location
- Solar diagram with altitude of the sun on June 21 and on December 21.
- Direction of prevailing winter winds
- Direction of prevailing summer winds
- Water displays (rivers, sea, lakes)
- Vegetation
- Any industrial settlements

From the analysis of climate data will then be possible to find:
- Value of direct and diffused radiation in order to understand whether to use passive and active strategies to produce energy and heat the room.
- Wind speed in support of strategies to increase natural ventilation.
- Amount of rainfall to evaluate the effectiveness of the rainwater harvesting systems.

The vegetation, the solar radiation and the sunshine become real design elements.
The idea of considering vegetation like plants, trees, meadows, shrubs, as building material reflects an awareness that in the organization of buildings or cities, real articulated system have been made since ancient times and built with the greenery which help to define the area of transition between the architecture and the city. It should also be noted that the greenery, apart from offering specific characteristics that require special conditions, for its own life, is able to change the existing environmental conditions, both climatic and morphological, transforming in a psychological and sensory way the relationship between man and environment. The greenery doesn't represent a static element, but as it undergoes constant changes both for the effect of the seasons, climate, ground conditions, transmits vitality within the environment and contributes to ensure the biological and psychological balance of men.

The vegetation has a great importance regarding in particular:
a) The shading of buildings and path to the ground, when the trees are isolated, in groups or arranged in rows, in the proper position respecting the apparent path of the sun in different seasons.
b)The windbreak effect on the area downstream from the dominant wind direction, when the trees are arranged to form a curtain of adequate height and density.



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Selection and design of the site
Quality of outdoors areas

Pic. 05 - Elementary school "Notley Green"

Description of the strategy

The open spaces attached to educational buildings, properly organized and promoted, are an important environmental, recreational and educational resource. These spaces must be designed to meet the different needs of students, especially those with psychological and physical deficits. These users have, in fact, not only special needs to meet, but also personal skills to accommodate and satisfy expectations. To develop the educational role of green spaces it is necessary to strengthen all the elements that provide the children with and without disabilities, strong visual, auditory, tactile, olfactory stimuli. The external environment should be designed to offer all users the same opportunities for development of physical skills, confidence and socialization and interaction with the external environment. It would be appropriate to facilitate the presence of educational gardens, and in the case of teenagers, a good idea would be to assign the managing of a small green area. It is important to avoid or eliminate the presence of dangerous plants and design the greenery, with consideration of its variation throughout the year choosing deciduous trees, as it allows us to observe the vegetative evolution throughout the school year, providing a strong support of scientific theories to practical tests provided by textbooks. The greenery can represent a real opportunity for the mental and physical development because young students, as a result of heavy urbanization, are forced to spend more time at home or at the gym, compromising their contact with nature. In the study of recreational areas there are concepts of urban planning, architecture, landscape, botanic, pedagogy, psychology, physical education, etc. and you need to combine a careful selection of specific plant species and a careful arrangement of furniture and games.

Target - Mediterranean area

The design of green spaces which regards the school construction must ensure:
- The control of the temperature and humidity
- The purification of air and water
- The shading and control of solar incident radiation
- The noise attenuation
- The protection from the wind
- The improvement of psychological and mental wellbeing
- The maintenance of the natural permeability of the soil that allows rainwater to penetrate into the ground at moderate speeds and diffusely, reducing the risk of fluid overload or flood.
- The possibility of outdoor recreational and educational activities

Norm Reference

Pay back period
Medium

Estimate of achievable saving
25%

Environmental quality degree of improvement

1	2	3	4	5

01.03
Quality of outdoors areas

Pic. 06 - M. Tribus- Primary school, Merano, Italy.
The aluminum pergola is used not only for the control of solar radiation but at the same time it creates a shaded space between the inside and outside.

Closer Analysis

The development design of a green space, cannot exclude a prior analysis of the people who are going to use it, because it's important to evaluate the complex of problems and needs expressed by students and to study the application of such requirements in the design of places. The main stages of a green space design can be summarized as follow:

1. Organization of the ground profiles and earthworks.
2. Acquisition of vegetal and inert elements.
3. Organization of the hedges.
4. Location of the main plant species.
5. Location of the planimetric areas with specific functions.
6. Organization of the volumes and the green garden proportions.
7. Study of the furnishings and the principles of landscape lighting.

The main functions of a vegetation space are:
"The adjustment of micro-climate": the reflection of the radiant energy and the cooling linked to the process of evapotranspiration significantly reduce the temperature of contiguous spaces. The perspiration is a process that removes heat from the surrounding air, and depends on the species of plants used. For example, the intensity of transpiration of some popular ornamental shrubs in the Mediterranean area during the summer months ranges between 229 and 1.686 g of water per day per square meter of leaf surface, which corresponds to a subtraction of heat between 133 and 978 kcal per day per square meter.
In order to ensure transpiration and shading it is better to use high trees and the use of large species must be balanced in relation to the operational and economic implications involved.
"The acoustic insulation":the noise protection consists in the reduction of the quantity and it improves the quality of the sound. It is obtained by using barriers, natural or artificial, which are that high that can alter the propagation of sound waves. The barriers made of trees and shrubs, if sufficiently large, can reduce the sound of 5-8 decibels. The plant softens the sound through the bark, branches and leaves. The human ear is more sensitive to higher frequencies and the plants through their foliage minimize them. The most suitable species are those with small and compact foliage. Moreover the attenuation of sound at low frequency depends on the spacing between the trees that create a kind of trap for radiation. The plants will also have an impact on the bright glare, reducing the refraction of sunlight and the surfaces or paved walls.
"The abatement of pollutants": the plants, together with solar radiation and soil, are the main factors of treatment of pollutants. In the choice of plant species to be included in the green spaces of the school, you should choose the conifers (generally evergreens) because they are effective even in winter, when there is more pollution. They avoid the deposit of pollutants into the ground. However, even plants with deciduous leaves are very useful, because they are able to remove the accumulation of pollutants through leaf fall in autumn.
"Aesthetic function": the element that gives the aesthetic impression to the vegetation may be the design, formal or naturalistic, the relationship between the flooring and the vegetal components, the presence of water, the use of patches of vegetation with blooms or foliage particularly decorative. The composition can be animated with different choices involving grass or low ground cover plants, shrubs and small trees. Moreover, if you identify panoramic views or views to be highlighted, you can use visual guided systems.

Closer bibliographical and web site analysis

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Pic. 07 - Gebhard Muller Discrict school centro Biberach.
In the school there is a 1.5-m3 tank for collecting rainwater.

Description of the strategy

The design or renovation of school buildings, must be integrated with the sustainable management of water resources in order to prevent:

1. The overloading of sewers or white mixed in the presence of exceptional weather events may be undersized, resulting in the phenomenon of flooding.
2. The release of excessive amounts of water in rivers, ditches or drainage canals leading to possible flooding of surface water.
3. The depletion of aquifers. The increase of the impervious surfaces reduces the amount of rain water which, penetrating in the soil, charges the flaps but at the same time increases the one discharged in the superficial surfaces.

The sustainable management of storm water within the school buildings has many advantages such as:
- The improving of the quality of urban areas around the school building.
- The saving of the energy: according to the "watergy" (a subject that studies the relationship between water and energy consumption), the energy consumption for the extraction, supply, distribution and water treatment can be reduced through water conservation.
- The reduce of the pollution and the aquatic ecosystems and habitats stress: the extraction of water from surface sources and groundwater pollution have a negative impact on the flora and on the fauna that live in the aquatic environments. The minimum vital flow and the loss of biodiversity are some of the consequences of an irrational and unsustainable use of water.

Target - Mediterranean area

The strategies for a wise water management resources consist of:
1. containment of rainwater draining.
2. recover and use of rainwater.
3. limiting as much as possible the permeability of soils, allowing the infiltration of rainwater into the ground.
4. the input of rainwater into surface waters

Norm Reference

D. Lgs 152/99, art. 39: the regions are responsible of the cases in which can be claimed that the storm water and washing of the outside areas are properly channeled and treated in treatment plants when there is a risk of the runoff from impervious opened surfaces or substances that limit the achievement of quality of water bodies (art. 39, comma 3).

Pay back period

Medium

Estimate of achievable saving

25 %

Environmental quality degree of improvement

1	2	3	4	5

01.04
The management of water resources

Pic. 08 - Bonn-Rhein-Sieg University. The rainwater coming from the roof is collected in a reservoir (the gap) at the entrance of the school building.

✶ Closer Analysis

The management of water resources can occur through:

1. A reduction in the consumption: through political awareness about water consumption in schools; the application of "intelligent" systems for monitoring; automated management of treatment plants; the use of control systems for bathroom fittings and washbasins.

2. The collection of rainwater: the basic components of a plant for the use of rainwater are: the "tank", placed both inside and outside the school building, underground or not, with the function of accumulating rainwater. The "baffle", with the function of separating the first rain water, full of pollutants, from those intended to be used for the accumulation for the next re-use. The "filter", installed upstream of the accumulation system, to prevent the entrance of debris inside the tanks. Other components are: the pump, the system of integration with drinking water, the sewers system of excess water. The recovered water can be used for: flushing of toilets, for the cleaning of the school, for gardening, for the cooling systems, having a water saving of 50%. Positioning the covers of the new settlements school roof garden, you can reuse up to 90% of rainwater, avoiding the overflow of sewage. Moreover, thanks to the effect of the greenery purification, the rain water in excess can be fed into the distribution system.

3. Construction of green roofs: (see slide 02.09).

4. Creation of "Biotopes": through the conveyance of rainwater in specific areas, you can create real wetlands of small size (such as a pond, a bog, a plateau) where animals and plants live. This creates a natural ecosystem propitious for the establishment of vegetation and wildlife.

5. "Permeable pavements": to reduce soil sealing in areas outside the school. However, it's better to check in advance that the subfloor and the subsoil have a sufficient permeability. In case of renovation, maintenance or extension it's possible to operate by replacing impermeable coverings such as asphalt, concrete or paving with cemented joints, with permeable paving, covered by the green for a better treatment of rainwater.

6. "Wetland": system for purifying waste water, whose effectiveness depends on the type of the school building. It's an ecological treatment of waste water which is done through the use of tree-shrub wetland plants and aquatic plants. These are systems that use aquatic plants based on the purification processes of the natural type and do not usually require any input of electricity. The capacity is known of self purification of natural aquatic ecosystems that can be populated by hydrophytes, floating or submerged. The principle is based on the capacity of the plant to absorb the various organic compounds dissolved in the water, concentrating them and converting them back into the living organic substances (flowers and leaves). In this type of system the polluted water is in contact at first with the bacteria inside the basin that decompose the organic pollutant substance in more simple inorganic molecules (nitrates, phosphates, carbon dioxide). These compounds are absorbed by the roots. At the end of the process, the water which comes from this type of system is without the polluting substances and may be reinserted into the environment. The "Wetland" plant is of low energy consumption and at the same time it's effective against pollution and it is safe for the environment.

Closer bibliographical and web site analysis

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Materials and construction technologies
Infill Bricks

Pic. 09 International Schooì, Torino

Description of the strategy

Most school buildings built from the seventies (DM 18-121975 technical standards for "school buildings"), are characterized by reinforced concrete structure and brick infill, or frequently plastered.

The brick is still one of the most commonly used materials in Italy, subject to continuous research, especially for public buildings (including schools), for the technical merits, for the sense of identity and belonging that brick construction can give in a specific urban context.

The material characteristics consist in mediating between light weights and mass, which makes it suitable especially in Mediterranean climates. A masonry wall ensures a healthy environment, the transpiration, good thermal and acoustic insulation values.Other characteristic of this technology are: duration in time, flexibility (easy installation, easy management and maintenance, easy integration of facilities and furnishings etc) and the structural reliability.

Heavy plaster can be used to enhance these skills by integrating the brick walls and additional layers of insulation or flexible loose joints. One of the most important aspects in the design of vertical opaque structures for school buildings in a Mediterranean climate area is the behaviour during the summer period of the structures, i.e. the ability of the opaque enclosure components to mitigate the phenomena of radiation in summer. Thanks to the new experiments in the field, some brick products, such as the "Honeycomb brick", can achieve high performance levels in both winter and summer, thanks to the characteristics of thermal insulation and high thermal inertia.

Target - Mediterranean area

The use of bricks in the design of school buildings maintains the Italian building tradition, and is in compliance with the regulations in terms of energy recovery and welfare housing, seismic and acoustic. The infill brick should ensure: soundproofing, insulation and thermal inertia, good static behaviour, easiness of installation and site safety.

Norm Reference

Pay back period

Medium

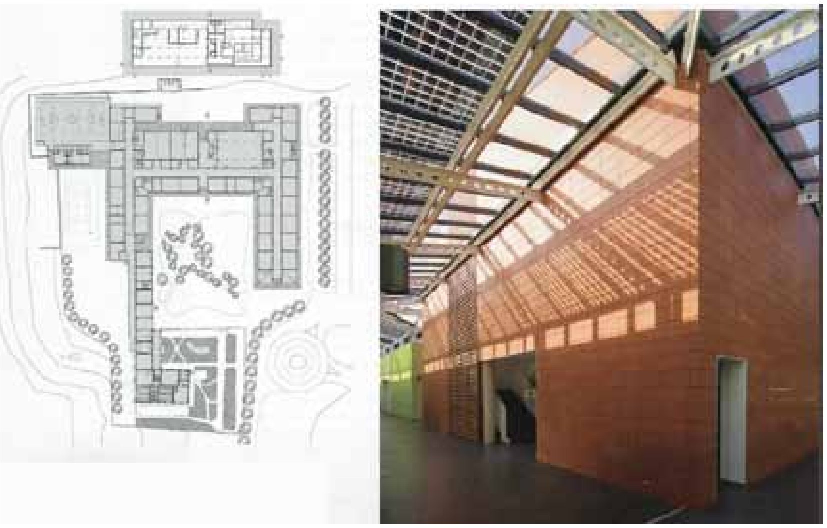
Estimate of achievable saving

30 %

Environmental quality degree of improvement

1	2	3	4	5

02.01
Infill Bricks



Pic. 10 -The new building uses the brick for both internal and the external environment. The intermediate cover is made of metal and glass with solar integration.

✶ Closer Analysis

The infill bricks are distinguished in:

a). monolayer infill, in which the thickness of the wall coincides with the size of the used element.
b) double-layer or multi-layer infill, consisting of two or more layers of brick, contiguous or spaced.
The design of masonry infill must meet the following requirements:
1. Earthquake security: the "Technical Standards for Construction", providing analysis and tests limited to infill with the technological characteristics, in order to assess the capacity of the brick elements to absorb the deformations of the structure subject to seismic action. At the points of structure contact, an elastic joint should be realized with a resilient material, able to absorb the deformations of the structure (because of the earthquake) and prevent the passage of water, air and airplane noise and has to contrast the transfer of sound energy to mechanical vibration.
The double walls must be rigidly kept through the use of connecting brackets, inclined towards the outside, to prevent the passage of any water of condensation towards the inner wall. To prevent the fall of the infill bricks and the expulsion of elements in the perpendicular direction to the plane of the masonry, it is necessary to insert steel networks on both sides of the masonry, connections each 50.00 cm, both in horizontal and vertical directions, and elements of horizontal reinforcement in the mortar beds each 50.00 cm.
2. Thermal performances: the thermal behavior of a vertical brick closure not only depends on the thickness, but also, and in a determining way, by the characteristics of the elements used and the type of realised joint. The thermal performance of the brick blocks are attested by the CE, which defines the resistance value of the single block, and not of the wall built with that block. The mortar has a thermal conductivity greater than the brick block that decreases, by about 10%, the performance of an entire wall. It is necessary to use the certification according to UNI EN 1745 of the specific block and from this deduce the value of the equivalent conductivity of the wall (λeq= W/mk). A design-oriented technical solutions brick provides, in addition to the respect of isolation requirements (D.Lgs. 192/05 e D.Lgs. 311/06), the reduction of energy consumption, thanks to the massive capacity of the individual elements. To avoid "thermal bridges" that may occur around the openings, the joint between wall and window frame must be made in a way so that the heat insulating panels can emerge from the cavity wall along the entire panel of the compartment.
3. Acoustical performances: not only depend on the thickness but also by mass, by the elasticity of the various parts and the overall quality of implementation. Walls of medium thickness, properly executed (continuous joints where provided, and elimination of lateral transmission of sound transmission, etc.), thanks to their ability to adequately answer to the massive values required by the standard for school buildings, walls and thick monolayer content have more difficulty to meet regulatory requirements, mainly because of the transmission side. In such cases alternatives may be had to the addition of insulating panels. For some years, the traditional brick was accompanied by the "" brick, obtained by putting additives in the uncooked clay, before the shaping step, a specific quantity of expanded polystyrene into small spheres of diameter between 1 and 2 mm, or other natural lighter elements (such as wood flour, rice husk, etc.). The "Honeycomb bricks", and the possibility to increase the thickness of the walls, give thermal-insulation, static and acoustic characteristics to the brick. (Moreover they achieve a good seismic performance obtained with premixed mortar using high thermal and mechanical performance).

Closer bibliographical and web site analysis

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http://www.laterizio.it/index.php?option=com_content&view=article&id=461&Itemid=219

Materials and construction technologies
Wood Infill

Pic. 11 - Kingsmead Primary School, North Ingland

Description of the strategy

The school buildings made of wood technology (widely used in northern climate countries and in the north of Italy), have also many advantages in the Mediterranean areas, from a viewpoint of energy saving, thermal and acoustic insulation, and seismic safety.
Thanks to the lightness of the structural elements, the infill and the high level of prefabrication, school buildings can be realized in a short time, with a result of a reduction of costs. Moreover, as wood has hygroscopic material properties, it acts as a regulator of moisture, ensuring the indoor welfare of school buildings, removing unpleasant smells and reducing the risk of mould, the main cause of the deterioration of sanitary conditions and environmental construction parts.
The infill, according to the stratigraphy, can reach U-values up to 0.14 W / mqK with phase shifts thermal wave up to 18 hours, and attenuation from 0.225 to 0.7 (higher values required by the current legislation). The careful planning of every detail of construction, together with the insulating properties of wood, give the possibility to have buildings almost with no thermal bridges. In the multilayer technology, you can achieve good levels of sound insulation, combining solid wood panels with natural insulation. Another property that makes the use of wooden structures appropriate in high seismic risk areas (typical in some areas of south Italy), is the lightness and elasticity of the structures that, with proper design of mechanical linkages, ensures a good response of the building in case of earthquake or strong wind. Finally, the wood can deal well with fire because of the low thermal conductivity and because of the fact that in case of fire, the water contained within the material, leaking out, creates a layer of protective coal.

Target - Mediterranean area

The main requirements of the casing made of wood technology are:
- high thermal resistance for the reduction of energy consumption;
- sufficient thermal capacity to maintain a comfortable environment with an adequate internal vapor permeability to prevent the formation of a superficial and interstitial condensation (UNI EN ISO 13778);
- good sound absorption values;
- good values of phase shift and damping of the thermal wave;
- lightweight and elastic structures and infill to resist the horizontal earthquake and wind.

Norm Reference

Pay back period
0 anni

Estimate of achievable saving
0%

Environmental quality degree of improvement

1	2	3	4	5

02.02
Wood Infill

Pic. 12 -Scuola primaria e dell'infanzia, Fabbriche di Vallico (Lucca)
La scuola è realizzata interamente con strutture lignee: legno lamellare per le travi curve di copertura, legno massiccio per i telai delle pareti, pannelli di compensato strutturale per i tamponamenti verticali.

✶ Closer Analysis

The different wooden construction systems vary according to the structural behaviour, aesthetic and architectural aspects and the construction details that make a suitable solution in certain contexts and for certain environmental climate. From a structural point of view, the technological systems achievable with the wood can be divided into:

- systems bearing walls (or heavy), in which the insulation is placed over the structure;
- systems in a frame structure, in which the isolation and the structure are located on the same plane.

The choice of the best solution in Mediterranean climates is related to the need to create isolation during the winter and at the same time ensuring good damping and phase shift levels of the thermal wave during the summer. One possible solution that meets these requirements is the panel technology supporting cross-laminated solid wood that is obtained by overlapping plates arranged orthogonally to each other and connected by bonding or riveting.

In the design of schools which uses wood technology it is necessary to pay attention to a series of measures: starting from the foundations, it is important to separate the construction by putting a curb in ca or wood. Moreover, in order to prevent the rising of damp through the walls, the foundation must be wrapped with a layer of bituminous sheath. This can also be used in areas of contact between the orthogonal walls, to prevent the passage of air or like an acoustic damping. The connection between the walls of the ground floor and the foundation structures, should take place through mechanical connections (hold down) that are designed to prevent overturning and sliding between the walls and foundations due to wind or seismic forces, and positioned at the end of the walls and near the openings. With regard to the constructive design of the packages of the walls, we can say that a first technical solution, in the case of schools situated in the Mediterranean area, is to place the insulation outside the enclosure.

In order to respect the transmittance values prescribed by law (Decree No. 311/2006), the insulation must be associated to the construction or structural element in one or more layers. The thickness can vary from a minimum of 25.00 cm to a maximum of 40.00 cm, depending on the material used. The insulating panels must have sound absorption characteristics and ensure the breath ability of the walls. For this reason it is better to use rigid panels made from natural materials that have a certain density such as wood fiber, rock wool, cork. In general, the wooden buildings are characterized by low values of surface mass. In order to control and limit the fluctuations of the thermal wave in summer, it is essential to choose some constructive packages characterized by good thermal resistance values (R), density and specific heat (J/kg K). In addition to the use of materials with performance requirements, it's important to check the position of the various insulation inside the package construction. The external finish can be achieved with plaster applied on a plaster mesh, which is necessary to avoid the formation of cracks at the joints of the underlying insulation panels or staves of wood can be used which are suitably treated with binder protective coat containing protective filter rays UV. From the inner side a gap must be realized of 2.00 to 4.00 cm for the passage of the plants, made of plasterboard single or double, and filled with mineral wool.

Closer bibliographical and web site analysis

Regione Toscana, *Linee guida per l'edilizia in legno in Toscana*, Edizioni Regione Toscana, *Firenze 2009*

http://www.indire.it/aesse/index.php

http://www.domolignea.it/

Materials and construction technologies
Plaster and natural finishes

Pic. 14 - School St Clément de Rivière, France

Description of the strategy

In recent years, there has been an increase of disorders such as allergies, headaches, loss of concentration, nausea within the school buildings caused by indoor air pollution. The indoor area can often be from two to five times more polluted than the outside area. This represents a significant value when referring to the educational buildings where students spend most of their day. In order to achieve a good well-being indoor, it's very important to pay attention at the internal microclimate, at the poor quality of construction materials and at the chemical origin of the low permeability of buildings. For the achievement of total well-being of the school building it is necessary to employ coatings formed from environmentally friendly materials that do not emit pollutants, along with mortars, plasters and natural paints that leave the wall to breathe freely.
In general within the school buildings, coatings must be:
Breathable: that could allow an immediate disposal of the indoor humidity, drying and making the school building livable from the beginning.
Hygroscopic: that is able to balance the moisture inside the house, absorbing and transferring the excess steam in case of excessively dry air.
Natural: plasters which do not give off dangerous volatile substances in the air and in the environment, and that can be recycled, for example as aggregates in the case of the plaster.

Target - Mediterranean area

Plasters applied outside the school buildings must provide:
- the regularization of the support surfaces;
- the tightening of the structures;
- the protection of the atmospheric agents;
- the thermal insulation and sealing of the air that is important also from the acoustic point of view;
- observation, in the case of clear plaster, of the solar radiation;
- the waterproofing:
- the improvement of the fire behavior of the wall;
- contributing to the aesthetic aspect of the school.

Plasters applied inside the school buildings must provide:
- the insulation;
- the dehumidification of school environments, often subject to condensation due to the number of users;
- the sound absorption;
- the elimination of thermal bridges.

Pay back period
Long

Estimate of achievable saving
30%

Environmental quality degree of improvement

1	2	3	4	5

02.03
Plaster and natural finishes

Pic. 15 - The classes oriented to the south are protected from direct sunlight by metal shielding devices (light shelves) that reflect directed light at the white ceiling of the classrooms.

✶ Closer Analysis

The coatings and the plasters, used in indoor environments of schools and as outer coating, have the function to protect from atmospheric agents, to ensure the welfare indoor, to avoid the phenomenon of condensation, to absorb moisture and to contribute to the aesthetic aspect of the building. The mortar for plastering normally involves more binders such as lime, gypsum, cement mixed with inert materials like sand. Depending on the types of components it's possible to make different kinds of plaster with special features such as dehumidifying plasters, waterproof, fireproof, soundproof, thermal insulation.
In particular:
Gypsum-based clays: they have a low environmental impact because the clay is worked raw and mixed with natural aggregates. The life cycle does not include cooking or special processes and at the end of the cycle, the material can be completely recycled or disposed as an inert material. They have a good thermal inertia that maintains a stable temperature of the environments. They regulate the humidity of the areas by absorbing the water from the air. In case of humidity conditions, they release it when the air is too dry, thereby maintaining the relative humidity under optimal conditions (50% and 70%). The clay has excellent acoustic properties, which is very important for places of large size such as laboratories and classrooms, where under normal conditions rumbles and unpleasant sound effects can occur. The plaster is then able to mitigate the low-frequency sounds. Finally, the clay, which is a colloid, has a great ability to retain the powder, and the gas.
Natural insulating plaster: the premixed plasters are made from cork, clay, natural additives and hydraulic lime, with functions of dehumidification and acoustic insulation. They can be used both for the thermal insulation of external walls, for the sound insulation between the school building and another adjacent unit or between the different environments of the school building. In the installation (which takes place in the same manner of a traditional plaster), to avoid the phenomena of cracking, it is important to provide corner reinforcements with glass fiber fabric embedded in the plaster. The insulation plasters also have the advantage of eliminating or significantly reducing the thermal bridges (thermal variable resistance between 0.35 and 0.90 make and W according to the types and thicknesses between 3 and 8 cm).
Plaster fire: they have the function of improving the fire resistance of the walls. They are made with hydraulic hoses, exfoliated vermiculite, expanded clay, aluminum silicate precipitate and fossil, without toxic substances like asbestos.
Acoustic plaster: they have the function of improving the sound absorption of the environments of the school building, thanks to the fibrous structure or to the open porosity. The plasters are doughy products. They are composed of inorganic binders or resins, fiber-based or mineral particles (aluminum, precipitated or fossil silicates, flow foams, "cristobaltite-amorphous" etc.) and have a total thickness from 1 to 4 cm. They also react well to fire.
Photo catalytic plaster: products based on photo catalytic cement. They act as a composite photo catalyst and are able to oxidize (in the presence of light and air) pollutants in the environment to form harmless residues. They are also composed of inert limestone, quartz-grade, special additives and possible colouring pigments. The application determines the development of self-cleaning, anti-pollution and anti-bacterial processes. Other important features to ensure the indoor well-being of the school buildings are the water vapour permeability, the ability to stick to any support and especially they generate antibacterial and anti-mould processes for the photo catalytic oxidation of the elements.

Closer bibliographical and web site analysis

A. Baratta, *Pareti leggere e stratificate in laterizio, edizioni laterservice*, Roma 2006
http://www.acca.it/euleb/it/home/index.html

Pic. 15- Hotel-management School in Nivillers (F), Tectône, 2000.

Description of the strategy

The principle of the dry layer construction, also known as S/C (Structure Covering), consists in assembling some industrially manufactured and certified elements/components directly on the building site according to an architectural –technological project.
The characteristic of the system consists in a clear separation between load bearing structure and other technical elements. Such elements have an independent structure and consist of light elements, functionally specialised and dry assembled with no dimensional limitations nor interface. In the gaps between the building shell surfaces and the structural link, specific sound proofing, sound absorbing layers, fire materials and multi functional coatings are placed.
The dry layer construction technology of school buildings offers the advantage of having infills through targeted performances according to exposure, orientation and distribution of interior spaces. Dry layer construction technology has been developed with the integration of "vigorously active layers" (capturing and screening) as photovoltaic panels, thermal solar, phase change materials, the latter help to delay and have a phase shift, especially in Mediterranean climates, of the waves of heat.
The systems S / C offers a number of advantages, such as the durability of dynamic systems, low environmental impact, they are easy to assemble and to disassemble and this defines a cyclical technology, reducing production times. Furthermore, the flexibility of the technology packages gives the designers some freedom regarding architectural and aesthetic expression, without the constraints of prefabricated systems.

Target - Mediterranean area

In the Mediterranean area, a system of multilayer wall dry must guarantee:

- phase displacement and thermal inertia via a controlled planning of the different layers;
- global stability of the package to wind and earthquake actions;
- thermal hygrometric comfort via the removal of thermal bridges;
- control of thermal contribution combining insulator, ventilation layer and external coating;
- acoustic comfort, through careful planning which has to consider discontinuities that can be found within the package, in the vertical escapes owing, for instance, to the lack of mortar of the masonry, or in peculiar parts, in the joints between doors and windows and masonry

Norm Reference

Pay back period

0 anni

Estimate of achievable saving

0%

Environmental quality degree of improvement

1	2	3	4	5

02.04
Dry layer construction

Pic 16- Hotel-management School in Nivillers (F), Tectône, 2000. Construction detail of dry layer facade.

✶ Closer Analysis

The dry stacked walls are characterized by a succession of layers divided into five macro entities:
1. External Covering
2. Stratification of isolated external cavity
3. Supporting structure
4. Stratification of isolated inner cavity
5. Inner cover

The main component of the building is normally constituted by a frame structure made of steel or laminated wood, but some solutions that use reinforced concrete frames are becoming popular, especially in the Mediterranean area.

With regard to the stratigraphy, starting from the external part, the system S/C is constituted by materials which are in general a little bulky, defined by soundproofing, sound absorbing, thermal-insulating, fire retardant, a steam barrier, waterproofing characteristics. Other components of the multilayer package are the links that can mechanically bring together the different layers , and softening elements located between the joints, to guarantee the elimination of thermal and acoustic bridges. Also placed inside the cavity are system networks which are easily inspected in case of faults and replaced with less energy and cost.

The technology of light multilayered walls, originates and develops in areas of Northern Europe, through the development of packages consisting almost exclusively of high thermal insulation thickness (even 20-30 cm), low specific weight and therefore low mass accumulation, with very low global thermal transmittance values (<0.15 W / mqK). In a Mediterranean climate zone a similar solution would create many difficulties in the summer. A solution for the Mediterranean climates, employs, within the stratigraphy of the external infills, materials with higher density and / or specific heat (such as solid wood panels like X-LAM, high-density wool and wood fiber, wood fiber, mineralized wood fiber, cellulose or hemp fibers, etc). The use of such solutions, even if in some cases allows to achieve excellent thermal periodic transmittance values and more than acceptable values of phase shift and implementation, does not allow, however, to achieve the appropriate values of thermal mass (-> 330 kg / m). The "hybrid" system fully meets these requirements, as characterized by a "skin" is well insulated and a "core" with some portions of elements and massive inertia. This way the performance of thermal insulation and thermal inertia are combined and architectures can be defined with the interactive environment according to the climate of each season. The most suitable insulators are mineral wools (used inwards with 15kg/mc with low density, for acoustic reasons and for the transit of the systems; outwards with high density of 60-70 kg / mc), or insulating panels based on wooden wool thanks to the fine properties of wave attenuation and thermal insulation panels with closed cells to the outside, (EPS or polyurethanes, excellent thermal insulation even with little phase shift power). The insulation of the thermal inertia can also be together with artificial thermal inertia which is programmable on desired temperatures, thanks to its positioning in the inner core PCM layers. The sound insulation, in the case of the system S / C is not based on the mass of materials, but on the dynamic behaviour which exploits the principle of resonance and coincidence, in which the masses, connected to the supporting structure (typically plaster-coated layers) , are separated by insulating mats and air gaps, which act as a spring.

Closer bibliographical and web site analysis

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http://www.consorzioesi.com/esi/tecnologia_strat_secco.html

http://www.casaeclima.com/

Materials and construction technologies
Shielding systems

Pic. 17 - Whitecross High School

Description of the strategy

classrooms exposed to the South-West, can adversely affect indoor comfort, causing the overheating of the classrooms during the hottest hours of the day as well as dazzling event near the windows and in the shadows in more distant parts. Integration of shading systems in the transparent parts of the covering, determines the distribution of direct radiation, creating, within the school environment, natural homogeneous light, with less luminance contrast. Actually, the incident light that on the thin layers can be intercepted, managed, filtered and reflected in various ways, in order to reduce the heating load in summer and to use the gains of heating in winter, without obstructing the external view and letting air pass for ventilation. The blades, moreover, are often used in cooling systems based on natural air flows, to channel and direct the wind. The shields, in case of transparent covers, deflect the light from above to spread it by reflection in depth. At present many schools lack sunscreens, or where they exist, they are badly designed without taking into account the orientation of the facade or without calculating the amount of light to be filtered in relation to the intended uses of the individual rooms.

Notes

The solar shading systems in schools can also be integrated with (opaque or translucent) photovoltaic technologies, or with phase change materials. Other types of shields are the green shields. Such shields make use of trees or climbing plants to control the summer sun exposure on a building. When systems with green facade are built with climbing plants, deciduous trees must be chosen, so as to allow shade in summer and sun exposure in winter. This type of screening has the advantage of influencing the microclimate around the building in a positive way as is the case of green roofs.

Target - Mediterranean area

In schools sun protection devices must:
1. Avoid summer overheating and the greenhouse effect;
2. Contribute to thermal comfort in winter, using materials that store heat during the hottest hours and then realizing it in the cooler hours;
3. Ensure the visibility of the external environment;
4. Ensure an homogeneous distribution of natural light, avoiding the dazzling event.

Norm Reference

UNI EN 13363-1:2008 – Sun protection device in combination with glasses - Calculation of solar and light transmittance, Part 1.

UNI EN 13363-1:2006 - Sun protection devices combined glasses - Calculation of solar and light transmittance, Part 2.

Presidential Norm 59/09 - Regulation for the implementation of Article 4, paragraph 1, letter a), b) of Legislative Norm 19 August 2005, n. 192, concerning implementation of the Directive on energy performance in buildings 2002/EC, Article 4, paragraph 19 and 20.

UNI EN 14501 - Thermal and visual comfort, performance characteristics and classification

UNI EN 13561 - External blinds, performance requirements including safety

UNI EN 13659 - Shutters, performance requirements including safety

UNI TS 11300 - Application of EN 1379

Pay back period

Medium

Estimate of achievable saving

30%

Environmental quality degree of improvement

1	2	3	4	5

02.05
Shielding systems

✶ Closer Analysis

The more suitable solar radiation control devices for school buildings can be classed in external shields, integrated shields, movable shields.
The external shields: they are suitable in summer and in Mediterranean climates because they avoid the internal temperatures to rise and by preventing the solar radiation to get through before it warms up the external elements of the building.
They are mainly divided into fixed and mobile shields.
- The fixed shields include structural elements such as balconies or roof overhangs as well as non-structural elements, such as external blinds or shading. The design depends on the orientation of the building, the shape of the opening and on the exposure. The horizontal shields should be of a "discontinuous" type (eg sunshade thin layers): in this way the accumulation of thermal loads is prevented in the upper part of the leaning out element while allowing the summer ventilation to be channeled towards the interior, in order to mitigate the accumulated heat. Since in the Mediterranean climate there is a need for protection from the sun in summer and heat gain in winter, it is essential to evaluate the choice of the screening type based on the orientation of the building. For those sides of the building facing South, horizontal shields must be used, while for sides exposed to East and West it is best to make use of vertical screens.
- The movable shields have several advantages such as avoiding the problem of thermal overloads that may build up on the fixed shelf, the presence of areas which are always in shadow and the reduction of visibility towards the outside. The support structure of these elements is generally detached from the rest of the building. As a result, a second covering is created, slightly apart from the main building. Such covering facilitates the air to be channeled between the two surfaces and facilitates heat dissipation. The design of blades or thin layers dimensioning and the distance between the various elements becomes extremely important as it directly affects the amount of light that will be screen or freely transmitted to the inside of the building. During the night, in winter, the shields will be closed to help limit heat loss through the covering. In summer, however, they will be fully open, in order to allow dissipation of any heat accumulated during the day.
- The integrated shields must be proposed during the planning stage and, although expensive, they are ideal because they allow schools to maintain a high level of visibility to the outside without discarding control Targets of solar radiation. They are divided into light refraction materials and components or into behavioral and variable characteristics. The first category includes glass or prismatic surfaces that allow to block and redirect the solar radiation; the aerogels, glasses with an interposal holographic film that reflects the direct solar radiation; TIM (with a low coefficient of thermal conductivity and high capacity of light transmission). Among the latter we can mention the so-called "active glasses" which change their light transmission characteristics according to the variation of the temperature (thermo chromic glasses) and the incident light (photo chromic glasses), or by artificially induced changes in the glass as it happens with electrochromic or LCD.

Pic. 18 - Vallisneri Secondary School in Lucca, Project: Lucca Administration, 2012

Closer bibliographical and web site analysis

Fabrizio Tucci: Involucro ben temperato, efficienza energetica ed ecologica in architettura attraverso la pelle degli edifici, 2006, Alinea Editrice.

Paola Boarin, Edilizia scolastica. Riqualificazione energetica ed ambientale. Metodologie operative, requisiti, strategie ed esempi per gli interventi sul patrimonio esistente, 2010 Edicom Edizioni.

Rosa Romano, Smart Skin Envelope. Integrazione architettonnica di tecnologie dinamiche ed innovative per il risparmio energetico, Firenze University Press,Firenze, 2012

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www.assites.it

Materials and construction technologies
Phase Change Insulation

Pic. 19 - Secondary School Simoni in Viareggio. Project: Lucca Administration and ABITA Research Centre (arch. Marco Sala, arch. Leonardo Boganini)

Description of the strategy

In the event that afternoon lessons or other extracurricular activities are provided for to be held it is appropriate, during the summer, that special attention is paid to limit the potential overheating of the covering in the hottest hours and extreme temperature changes between day and night. Phase change materials, known as PCM, are part of the category of materials called “active”, because they can react to outside weather conditions. PCM are latent heat accumulators and exploit the phenomenon of phase transition to absorb the energy flows incoming / outgoing from the covering, by storing a large amount of energy and while keeping its own temperature constant. When the temperature decreases, PCM solidify transferring heat to the environment, while they liquefy, accumulating heat that is taken from the environment, when the temperature increases. Since the T ° diffusion / solidification is equal to about 25 ° C, these materials allow to optimize the performance of the masonry in summer conditions favoring the softening and the attenuation of the thermal wave. Experimental studies on specific materials of the PCM category have shown that the application in warm climatic regions (Central-Southern Italy) reduces energy consumption and carbon dioxide emissions by about 20% and improves comfort in summer and winter. PCM currently available are organic compounds and paraffinic hydrocarbons obtained as by-products of oil refining or polymerization, and as some inorganic hydrate salts. They can also be used: loose, with microencapsulation, soaked in porous matrixes.

Target - Mediterranean area

In the Mediterranean area, phase-change materials integrated to the opaque and / or transparent covering, contribute to the improvement of inertial performances.

On the internal surfaces they contribute to:
- Reduce temperature fluctuations;
- Reduce energy consumption for air conditioning;
- Increase the microclimate comfort.

On the external surfaces they contribute to:
- Reduce the heat load in summer;
- Reduce energy consumption for air conditioning;
- Increase the microclimate comfort.

On glass surfaces they contribute to:
- Reduce temperature fluctuations;
- Increase the heat gains;
- Reduce energy consumption for air conditioning.

Norm Reference

Pay back period
Long

Estimate of achievable saving
30%

Environmental quality degree of improvement

1	2	3	4	5

02.06
Phase Change Insulation

Pic. 20 - Secondary School Simoni in Viareggio. Project: Lucca Administration and ABITA Research Centre (arch. Marco Sala, arch. Leonardo Boganini)

Closer Analysis

Phase change materials enhance the inertial performance of light weighted school buildings and are a good solution for the recovery of existing with little mass buildings. PCM, actually, allow to obtain the phase shift of the thermal wave while using reduced thicknesses, and to program the thermal wave according to the temperature to be obtained. The compatibility between the PMC inertial layer and the Structure / Covering, allows the opaque covering to be used inside or the outside of the opaque covering, which is integrated to the transparent, covering, flooring, and integrated surfaces to the shields. Specifically, the phase change materials can be found:

- Integrated to the plasterboard panels: they are innovative panels with the plaster core modified with PMC materials, and glass fiber coated. They are generally installed on a wall or as false ceiling, metal or wood texture and with the same modalities of the plasterboard panels. The mixture of the sheet contains microspheres with paraffin material, able of storing energy.
- In plasters: they generally consist of wax microcapsules of microscopic size contained in a layer of plaster, and they allow to maintain pleasant temperatures inside buildings. They are latent accumulators of heat, which is absorbed during the fusion of the wax itself, and then it is released when the wax solidifies. These wax microcapsules are protected by a plastic covering, so as not to escape from the plaster, during the phase change of the liquidation;
- In place of an air hollow space between the sheet of glass (or plexiglass) or in addition to it, with appropriate shielding or reflective sheet. The system generally consists of four layers of glass with three hollow spaces containing, starting from the outside: sunshade panels and noble gases, noble gases, phase change panels. This way good values of thermal inertia and natural diffused lighting inside with reduced thicknesses can be obtained;
- Integrated to technology and air conditioning systems and system solutions, such as heating, cooling, solar collectors and heat exchangers.

The phase change materials should not be toxic, corrosive or hygroscopic to be applied inside school buildings. PMC must have a fusion temperature of about 25 ° and a high enough phase transition heat (both for liquefaction as well as for solidification).

Closer bibliographical and web site analysis

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SCHITTICH C., a cura di, Involucri edilizi. Progetti, strati funzionali, materiali., Detail – Birkhauser, Monaco – Basilea, 2003

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http://www.icynene.com/

Materials and construction technologies

Roof Garden

Pic. 23 - The Singapore art school is a building which hosts the Design and Media school and the Nanyang Technological University. The two "hills" with stairs are accesible to students who can enjoy in complete freedom their break moments. Besides establishing an active relation with the surroundings, the natural ceiling functions as insulator and air purifying.

Description of the strategy

Green roofs are a good solution for the existing school buildings and new constructions, located in densely urbanized areas, for aesthetic and environmental value that is added to the urban context as well as to the building itself.

In these "high-altitude gardens and allotments," students can enjoy a green site, while remaining in the city, they can have outdoor lessons and cultivate special plants, useful support tools for teaching. In this way environmental education is combined with a healthier environment and cleaner air. The green roof is an excellent thermal and acoustic insulation (with a reduced acoustic reflection of 3db, and acoustic isolation of 8dB). It increases the thermal inertia of the roof, and it acts as a filter for pollutants, retaining dust and harmful substances. Furthermore, in Mediterranean climates it helps to cool and humidify the air. Also important are the economic advantages, regarding the costs of heating and air conditioning, as well as the enhanced value of the property. The green roof has also got the ability to prolong the duration of covering, because the impermeable layer is protected from UV rays, hail, the heat and the cold.

In Italy the culture of the roof garden is not very popular as far as design of new school buildings are concerned, especially because of the doubts concerning the issues of irrigation, waterproofing and maintenance, while almost none are used in the recovery of existing buildings, due to seismic problems that may result from overload. However, today the problem of irrigation is solved with systems aimed at minimizing water consumption, thanks to sophisticated control systems that prevent water loss and allow the use of the sub-irrigation, or simply make use of essences with little water needs.

Notes

The Green roof improves the efficiency of solar panels, as it avoids loss of performance due to high temperatures.

Target - Mediterranean area

- Functional use of coverage: through the creation of a space suited to carry out outdoor educational and leisure activities;
- Improving the environmental performance inside the building: through facility of a green roof to insulate thermally, thanks to its mass, as well as to store heat during the hottest time of the day, so that the heat can be slowly used during the colder time of the day (phase shift of the thermal wave);
- Improved acoustic performance through the facility of the green roof to reduce sound reflection, and to improve the sound insulation;
- Improvement of the external environmental condition of the school building, in relation to the facility of the green roof to absorb dust, to act as a possible element of sound absorption and water drainage as well as of mitigator of temperature;
- Environmental compensation: facility of the green roof and of the architectural system to return all or part of the values that the original system gave to the environmental context.

Norm Reference

UNI EN 11235:2007 - EC 1-2008, EC 2-2009d instructions for the design, execution, control and maintenance of a green roof.

UNIEN13041- density of the culture layer O> 350 g / l <100 g / l

DIN 18035: degree of reduction of the volume to the compression of the culture layer LK 100

DIN 18035: permeability:

- Intensive roofing (LK 100)> 0.3 mm / min;
- Extensive roofing (LK 100)> 0.6 mm / min.

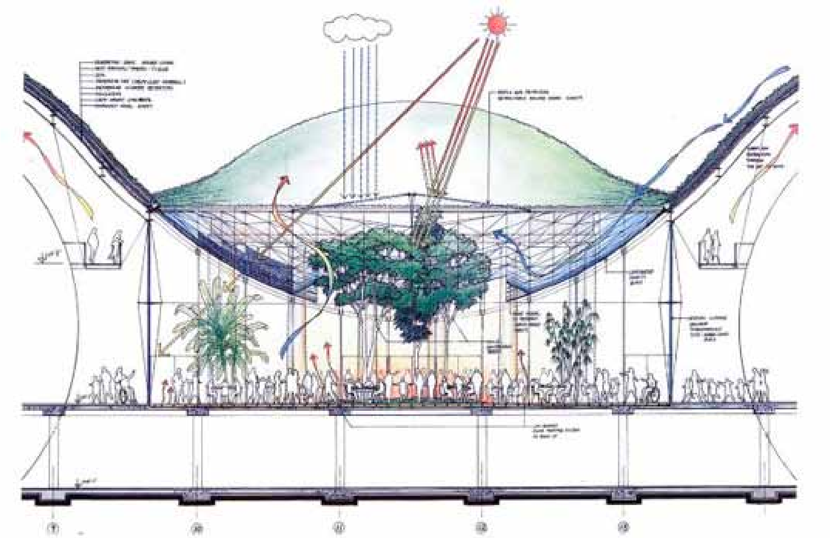
Estimate of achievable saving

35 %

Environmental quality degree of improvement

1	2	3	4	5

02.07
Roof Garden



Pic. 22 - Renzo iano, California Academy Science, San Francisco, 2006. The museum's roof is developed as a garden roof to avoid summer overheating events.

✶ Closer Analysis

The planning to have a green roof in schools must start from a clear identification of those requirements which have to be met. If the goal is to improve thermo-acoustic insulation of the interior, the solution is to choose the extensive green roof. These are lightweighted, have less saturation load, which may vary from 100 to 200 kg/m2, and since they have reduced water storage capacity, they do not require special irrigation or maintenance. It is preferable in any case to provide for a small automatic irrigation system in the event of unexpected seasonal rainfall. Among the suitable plants there are several species of sedum, herbs and some grasses. After the vegetation has taken root, maintenance is limited to one or two inspections a year.

If instead, when building from scratch or upgrading schools, the goal is to have a functional space, which is to be assigned to certain learning and outdoor activities, or to blend the building with the landscape. If there are not any problems concerning the sizing of the facilities, the choice can shift to the hanging gardens. In this case, an overload of 400-750 kg/m2 will have to be expected as well as an increase in thickness of about 15 cm. Maintenance must be regular and depends on the landscape architecture as well as on the plants that have been chosen. Any solution is possible: lawn, perennial plants, shrubs, trees, but also other options such as ponds, pergolas and terraces.

From a technological-constructive point of view green roof coverings consist of the following basic stratigraphy:

1. Main structure to test against the expected overloading;
2. Any isolation (in living and heated units and when the cultivation layer consists of a small thickness), made with thermo-insulating panels, after the application of steam barrier between the floor and the insulator;
3. Leaning screed, greater than or equal to 2%, made with a blast of lightweight concrete;
4. Waterproofing;
5. Anti-root layer, to protect the waterproofing cladding from the action of infiltrating roots;
6. Drainage layer made with suitable materials, able to drain the excessive water, and at the same time able of retaining a bit of reserve humidity, which is necessary to the life of the vegetable layer;
7. Filtering layer, fiber non fiber fabric, with the function of preventing the soil from clogging the drainage layer;
8. Cultural layer of earth, soil or compost with a thickness ranging between 10-15 cm for green roofs with turf or perennial herbaceous plants, small shrubs from 20-25 cm, up to a meter for trees with long trunks;
9. Vegetable layer, a functional and aesthetic refinement of the cover, adapted to the thickness of the substrate and to the climatic conditions of the area;
10. Any irrigation system.

Closer bibliographical and web site analysis

Paolo Abram, Il Verde Pensile, Sistemi Editoriali, Napoli, 2011

Annibale Sicurella, Progettare il verde, Sistemi Editoriali, Napoli, 2010

Daniela Bouvet, La vegetazione nel progetto, Sistemi Editoriali, Napoli, 2007

http://www.daku.it/

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http://www.greenroofs.com/

http://www.greenroofs.org/

Materials and construction technologies
Ventilated roof

Pic. 23 - South Facade, Secondary School in Rome., project MSA (arch. Marco Sala, arch. Rosa Romano, arch. Leonardo Boganini, arch. Alessandra Carta) 2011

Description of the strategy

A ventilated roof can be called such when the cover mantle detaches from the insulating layer creating a hollow space which permits the circulation of air. The upper layer of the cover, subjected to radiation, transfers the heat to the lower air, starting a convective motion which helps hot air to flow out through the hipped roof. The creation of these ventilated air space and the following chimney effect reduces the creation of condensation, keeping the insulating layer dry in winter and efficiently contributes reducing high temperature in summer, helping to drain quickly the excessive humidity and to guarantee the efficacy and durability of the cover, permitting a remarkable energy conservation and a cheaper maintenance.
In order to guarantee the starting of the chimney effect is necessary that the roof has a certain leaning and the height of the hollow space is in relation to the length of the pitch and to its leaning; moreover is very important that inside there is some air which can come out of the opening on the air space and be substituted from other air coming from outside and that exist a difference of temperature between external air and the air under the roof.

Notes

The efficacy of the airy cover depends on the dimension of the thickness of the airy layer. An excessive dimension can cause a decrease of the speed of the fluid and, in winter, a decrease of the temperature in the layer, such to prevent the starting of the necessary convective motion. Yet, for longer pitches or limited leanings, is necessary a bigger air blade and its thickness must be calculated on the basis of precise proportional coefficients. The threshold of 5/6 cm determines the difference between macro and micro ventilation. We have an airy roof with a hollow space longer than 5/6 cm up to 10. In case the pitch is longer than 10 cm and has a leaning of 26%, the thickness of the air blade must be 10 cm.

Target - Mediterranean area

As far as the Mediterranean climate is concerned, a ventilated roof has the great advantage to reduce overheating of the horizontal closings during summer, avoiding an excessive increase of the temperature in the rooms located under the roof. The presence of air, moreover, which functions as a thermal insulating, permits to reach good performances in terms of transmittance and thermal inertia, without affecting too much the realisation costs.

Pay back period

Long

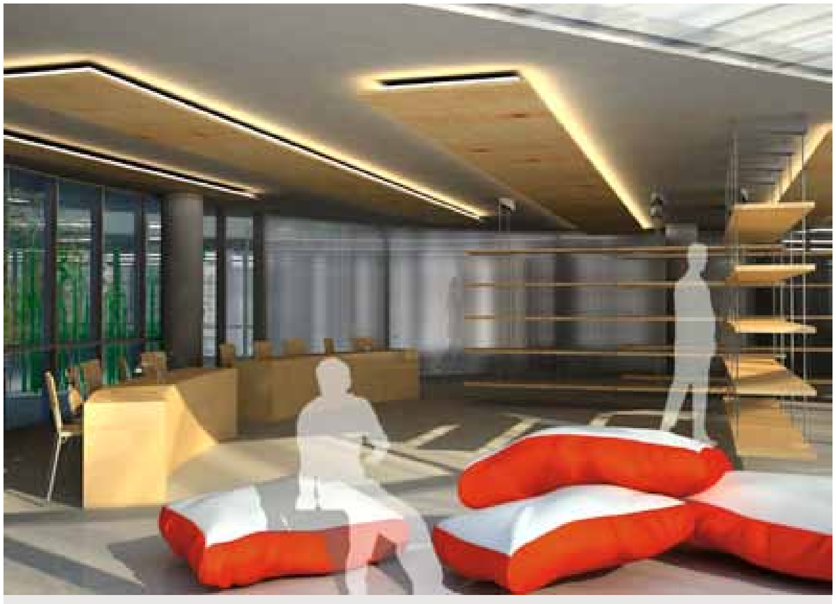
Estimate of achievable saving

30 %

Environmental quality degree of improvement

1	2	3	4	5

02.08
Ventilated roof



Pic. 24 - Library, Secondary School in Rome., project MSA project MSA (arch. Marco Sala, arch. Rosa Romano, arch. Leonardo Boganini, arch. Alessandra Carta) 2011

✶ Closer Analysis

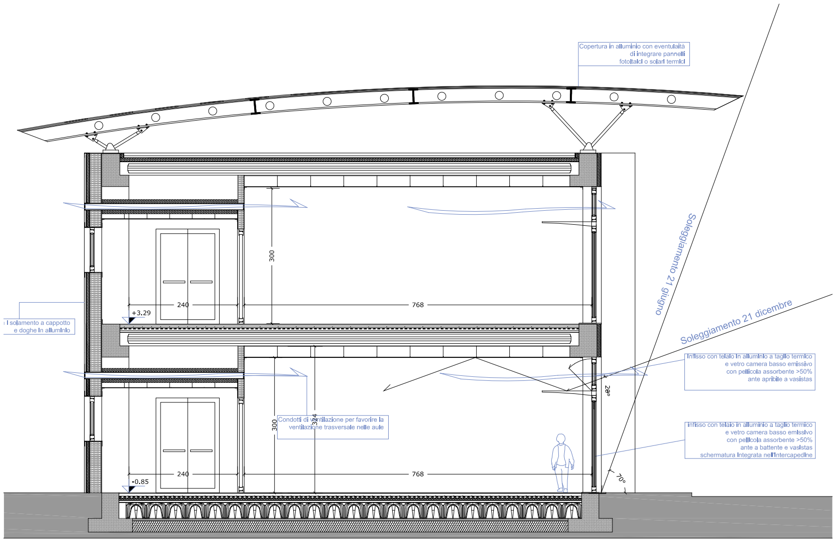
We should also say that rarely ventilation is sufficient to guarantee comfort in the rooms located under the roof, if it is not combined with a good insulation against heat; in fact during the periods of exposure to daylight, the temperature on the cover mantel can reach and be over 80° C, so it would be impossible to drain the heat energy which will hit also the insulating layer.

If ventilation is really important in summer, especially with isolated light structures with low power and volume density (synthetic materials such as EPS and XPS), it is true that even when we use an insulating system against the cold it is important to adopt ventilation, as it offers numerous advantages during the whole year.

The use of an airy roof can bring numerous advantages.
Besides the thermal benefit for the inner rooms during summer coming from a lower thermal stress on the insulating layer, ventilation permits the elimination of condensation, one of the main causes of the deterioration of the components, preventing the insulation from getting dry, impairing also the lower structure.

Ventilation can also permit a draining of the internal humidity if combined with an insulating and at the same time breathable layer, protecting in this way the cover; moreover, being the temperature of the air in the hollow space very similar to the external one, also the cover will be less exposed to stress, differential conditions and frost – thaw cycles with an obvious increase of its duration.

As far as the limits of the airy roof are concerned, as regards to its summer efficacy, the advantages of ventilation are remarkable only if the insulating layer cannot protect from heat; on the contrary, if this layer already offers a good protection from heat, the presence ventilation is unremarkable or even imperceptible



Pic. 25 - Majorana Secondary School in Capannori, Lucca, 2011. Technological Section. Project: Lucca Administration and ABITA Interuniversity Research Centre

Closer bibliographical and web site analysis

Marco Sala, Integrazione Architettonica del Fotovoltaico, Casi studio di Edifici Pubblici in Toscana, Firenze, Alinea, 2003.

Gaetano Melzi, Dizionario di opere anonime e pseudonime di scrittori italiani o come che sia aventi relazione all'Italia, Milano: L. di G. Pirola, 1848-1859, 3 volumi

www.enea.it

Materials and construction technologies

Tower systems for passive ventilation

Pic. 27 - Global ecology research centre, Stanford, California

Description of the strategy

Passive ventilation systems are based on the starting and increase of internal ventilation thanks to some architectural elements such as ventilation chimneys and 'wind towers' which are able to capture external draughts and to admit them within the building, permitting a convective ventilation of the internal heat with a lot of benefits on the thermal balance.
This idea is based on the difference of pressure which is created when high pressure areas are linked to low pressure areas, generating in this way movements of air masses; the bigger is the difference between the height of the two areas, the better this system works.

Notes
The amount of external air is usually expressed in m^3/h per person.
The American standard ASHRAE 62-1989 (American Society of Heating, Refrigerating and Air-Conditioning Engineers), Ventilation for Acceptable Indoor Air Quality, presents the recommended emission volumes of external air in order to avoid damaging effects on health and make the environment comfortable. The European standard CEN TC-156 defines instead three different categories of air quality taken as a point of reference in order to dimension the ventilation systems; a formula permits to calculate the amount of external air necessary on the base of the percentage of satisfied occupants, of the quality of external air and of the polluting load of the environment.

Target - Mediterranean area

The ventilation chimney is an architectural solution that has been used
for centuries in central Asia and in the Middle East. Several passive strategies have been introduced in the traditional architecture of these areas in order to reduce temperatures during summer taking advantage of the natural ventilation and using architectural solutions dedicated and very similar to the local architecture, such as:

- the malqaf
- the badger
- the meneh.

In the Mediterranean Area ventilation systems integrated in the covering are the 'trulli' in Puglia, where the holes for ventilation are placed on the smokestack and guarantee a nocturnal transverse ventilation to drain warm air during summer.

Norm Reference

CEN/TC 156 – Terminology regulation, proof and evaluation methods, dimension and capacity for natural or mechanical ventilation systems and the components of buildings with people.

DM December 18 1975 – Technical updated laws about school building, included indici di funzionalità didattica , building and town planning, to be respected in the realisation of school building works, art 5.2.2 and art 5.2.5.

UNI EN 13779:2008 – Non residential buildings ventilation – Service requirements for ventilation and conditioning systems.

Pay back period

Long

Estimate of achievable saving

25 %

Environmental quality degree of improvement

1	2	3	4	5

02.09
Tower systems for passive ventilation

Pic. 28- High School, Petaluma, California

✶ Closer Analysis

Tower systems for passive refreshment can be distinguished on the basis of the configuration of air flows within them in:

- Downdraught systems, where the "tower" which passes through the top opening placed against the wind catches the wind starting a descending movement of the flows, generating a movement of air masses in the rooms because of the difference of pressure between the fireplace mouth and the downwind openings. A particular system for passive refreshment in descending air flow is PHDC, Passive and Hybrid Downdraught Cooling, which combines the ventilation system with that of water evaporation. During the evaporation process, the temperature of the water decreases, generating a downdraught.

- Ascending draught systems, where we have an upward motion of the flows through the tower; the wind is caught through specific openings or windows, placed on the side of the building which is against the wind (high pressure side) causing the entry of the air masses with a ventilation of the inner rooms and the following extraction through the chimney, whose top is designed as to create an area of low pressure, so that air masses from the high pressure area can be attracted.

- Settings with mixed function, characterised by both upward and descending air flows, which permit to increase the efficiency of the passive refreshment system without considering the direction of the main wind (and soon the difference of pressure of the different zones) to which the extraction and capture systems refer. The chimney can be divided into two sections, each with its own mouth orientated in the opposite direction than the other one, one against wind, the other downwind, permitting in this way a mixed working. The movements of air masses, in fact, can be started not only by a different pressure, but also by a different temperature; during the night the tower gets cold and during the first hours of the day determines, through a contact with the walls, the cooling of the air which, once colder, becomes heavier and descends; during the night, the heat accumulated within the walls of the tower during the day, determines flows of warm air which are lighter and create an upward draught which comes out thanks to the downwind opening.

Pic. 29 - Short and Associates, School of Slavonic and East European Studies, London

Closer bibliographical and web site analysis

Schiano-Phan R. 'The Development of Passive Downdraught Evaporative Cooling Systems Using Porous Ceramic Evaporators and their application in residential buildings', Plea 2004 The 21st Conference on Passive & Low Energy Architecture, Eindhoven, Netherlands, 19-22 September 2004, (ISBN: 9038616368) Vol. 2, pp. 1249-1254.

Givoni B., 1994. Passive and Low Energy Cooling of Buildings.

Francis E., Cucinella M., Passive Downdraught Evaporative Cooling, PLEA 2000 Architecture and Environment, conference proceedings.

Claudio Renato Fantone, Short & Associates, Involucri intelligenti per una scuola di alta formazione, Costruire in laterizio, n. 116, pp. 46-53

Promotion and Dissemination of Passive and Hybrid Downdraught Cooling in Buildings www.phdc.eu

Materials and construction technologies

Smart windows

Pic. 30 - The new triangular school building by architects Christensen&Co, Horsholm, north of Copenhagen, Denmark, not only produces more energy than it needs, but offers to the children, in spite of its compact shape, perfect natural lighting conditions.

Description of the strategy

In schools transparent closures are particularly important both to let light in and to control thermal dispersions, air permeability and acoustic isolation.
More natural light inside the building causes a higher productivity of the students, more concentration and the possibility to make up for the costs for the control of solar radiation.
Moreover a good sight of the external environment helps to avoid cases of alienation and isolation, helps the orienteering capability connected to the sight of the elements on the horizon, produces in the users more comfort and self-confidence (we know that in case of danger we can escape immediately outside).
Many schools use frames without thermal cut, assembling them along the holes, without double glazing and with low acoustic protection, causing in this way bad thermal services but also acoustic pollution, with a following indoor comfort decrease.

Notes
For some school buildings located in populous areas it can happen that windows cannot be open to refresh air because of acoustic pollution coming from outside, and this negatively affects daily activities. In this cases is necessary to install controlled ventilation systems in order to guarantee fresh air in even without opening the frames.

Target - Mediterranean area

The substitution and/or design of frames in school buildings must guarantee:
1- internal visual comfort: reduction of dazzling, shadows control and variation of luminous intensity, transparency to sun rays.
2 – internal ambient comfort: reduction of overheating in summer and thermal dispersions in winter; reduction of sudden changes in temperature caused by a different temperature of the window frames and glass respect to the external environment.
3 – Acoustic comfort frames must guarantee a good acoustic isolation and no vibrations caused by sound waves.
4 – Strategic placement of the windows, also the no energy saving ones, considering the north south orientation of the walls and possible shade covers in order to guarantee solar advantages but also a good natural ventilation.
5 – Crash safety

Norm Reference

Dlgs 322/2006 - Disposizioni correttive e integrative al decreto legislativo 19/08/2005, n.192, recante attuazione della Direttiva Europea 2007/91/CE relativa al rendimento energetico nell'edilizia.

Pay back period

Long

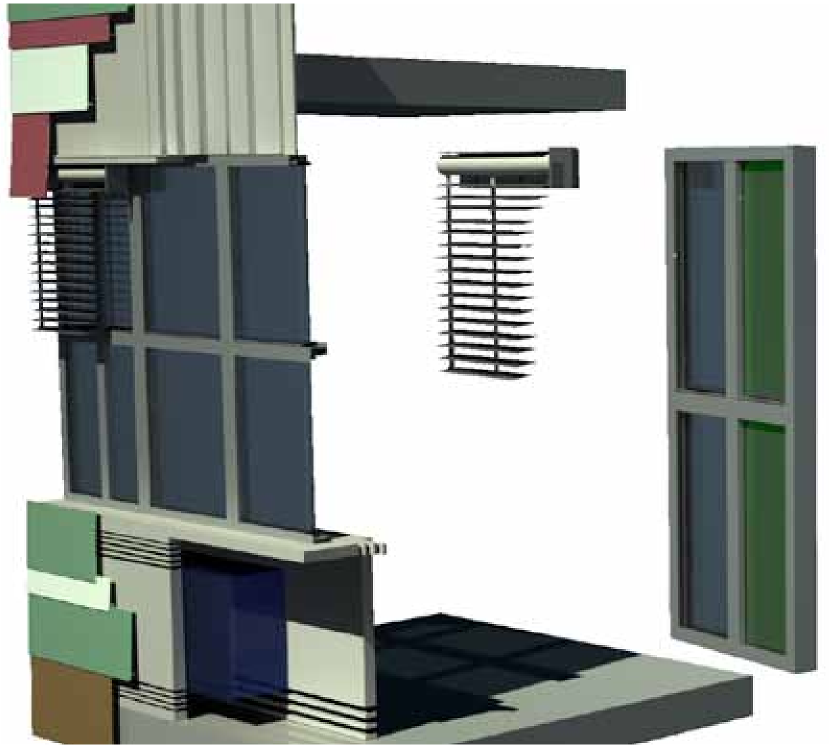
Estimate of achievable saving

From 10% to 20% depending on the thermal transmission of the adopted frames in comparison to the previous ones and to the extension of glass surface.

Environmental quality degree of improvement

1 2 3 4 5

02.10
Smart windows



Pic. 24 - Smart window with heat change, Secondary School in Rome., project MSA project MSA (arch. Marco Sala, arch. Rosa Romano, arch. Leonardo Boganini, arch. Alessandra Carta) 2011

✶ Closer Analysis

The strategies that we should adopt for the design and/or substitution of the frames are mainly related to the orientation of the building, to the characteristics of the window frames (which is responsible for the duration and thermal cut), to the spacer (responsible for the condensation along the sides of the double glazing) and eventually to the disposition. During renovations of old buildings thermal dispersions can be avoided substituting multilayer glass with double glazing, better if filled with air or inert gases (such as argon and krypton). Also the use of low-emissive films on the internal surface of the room affects the improvement of performances, letting solar radiation pass through almost completely (at highest frequency), but preventing the low frequency radiation from passing through (infrared), that is the 'thermal' component of sun light. Among the disadvantages in the use of low-emissive films we can find: no seasonal adaptability caused by the fixed covering, a no uniform distribution of the natural light, a change of the colour of the light which penetrated and a 20% loss of luminous transmission (TL).

As glass, besides low-emissive glasses we could use Tim (Transparent Insulation Materials); angular selective glazing (Okasolar glass), prism glasses (for skylights), acoustic glasses. Tim glasses have got thermal properties similar to the opaque materials, but preserve a high value of luminous transmission and guarantee a good distribution of light even in rooms with relevant depths. Yet, their no transparency (they are translucent materials) reduces visibility between internal and external environment. Okasolar glasses, thanks to the system of integrated thin layers, are part of the angular selective glazing and their shape and material permit to control the direction of the radiation; they are perfect for schools because they reduce heat during summer; permit a uniform distribution of light; guarantee a good visibility outside; help to reduce dazzling. Prism glasses which can be used with transparent surfaces are made of a plastic texture covered by a thin high reflection layer of aluminium; they are the best solution for Mediterranean climates because reduce summer heat, guarantee a uniform distribution of day light and protect from dazzling. Acoustic glasses are made of a thick plate, associated to another one, which is about 30% thinner than the first one. The thermal acoustic services of these glasses can be increased combining low-emissive glasses and argon or krypton to fulfil the hollow space.

The mounting of frames can damage the thermal – acoustic services of the element if not carried out properly: particular attention must be paid to the anchorage of the frame with the wall, making a overlap with insulation panel and using particular tapes for airtight. In this way heat bridges will be eliminated and the formation of condensation on the bench will be avoided.

Closer bibliographical and web site analysis

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Paola Boarin, Edilizia scolastica. Riqualificazione energetica ed ambientale. Metodologie operative, requisiti, strategie ed esempi per gli interventi sul patrimonio esistente, 2010 Edicom Edizioni.

http://www.schueco.com/web/it

Pic. 32 - Secondary School "Giovanni Pascoli", Bolzano, Project: arch. Ranzani

Description of the strategy

Double skin facades can be considered a technological evolution of the 'curtain wall' following its rules of mounting; these systems are a solution for architectural approaches which aim at reducing energy consumption.
The technological characteristics of a similar façade are an internal and an external skin, a hollow space within which air flows and other layers, creating a multiple façade system where particularly important are the speed and the flow of the air (captured both outside and inside of the building) that is recorded in the hollow space because in this way we can exploit natural ventilation in those buildings which cannot benefit of this possibility.
These systems can be divided in three main categories: natural ventilation, pressure compensation or forced ventilation; in this last category it's important to combine the façade automation with the air conditioning system in order to guarantee the necessary fresh air both in summer and in winter.

Notes
Transparent double skin facades with natural ventilation are less demanding from a building point of view and cheaper than the other types because they don't need sophisticated ventilation systems and they don't need a high tightness on the external skin closings.
Its composition is the following:
- external façade with monolithic glass panels or cladding;
- a hollow space with a dimension of 50,00 to 90,00 cm where some devices for the sun control are placed;
- internal façade in double glazing or passive opaque covering.

Target - Mediterranean area

The energetic services of a double skin façade depend on the climate and on the specific treatment of every single façade, which changes according to its orientation. We can state that in the Mediterranean area in a transparent double skin facades building the energy consumption is higher in summer than in winter, whereas natural ventilation is more effective in summer, because upward flow of air is helped by higher heat energy accumulated by the surfaces more exposed to the sun.

Norm Reference

Pay back period

Long

Estimate of achievable saving

20 %

Environmental quality degree of improvement

1	2	3	4	5

02.11
Double skin façades

Pic. 33 - Secondary School "Giovanni Pascoli", Bolzano, Project: arch. Ranzani

✶ Closer Analysis

We can choose the correct kind of façade and its working process only on the basis of specific conditions of the project, such as climatic conditions, the predominant winds and the pressure on the skin of the building, the acoustic pollution, the dimensions of the rooms and the mechanical systems of aspiration.
The services of a double skin façade will depend on several factors, the most important of all the difference in pressure caused by chimney effect. External air enters in the in-between space of the façade only through the air vents, usually smaller than the depth of the corridor, so that a peak of speed and a following decrease of the pressure within the hollow space are generated; in order to improve the effect of upward air flows is necessary that the dimension of the upper opening of the 'chimney' is double than the lower one.
The presence of air vents permits to have a system of changing facade which changes according to the season, closing both air vents in winter so as to use the greenhouse effect, and opening them in summer letting the excessive heat in the hollow space flow out.
The design of the hollow space can be carried out with no particular dimensional commitments; to its increase corresponds a small and unremarkable decrease of air temperature, whereas a continuous hollow space causes difficulties connected to the correct ventilation of internal rooms, because there is the risk of mixing between the air expulsed from the lower rooms and that which enters from above; we can avoid this problem sectioning the hollow space on the basis of the different floors and of the single functional units.

There are some advantages in the use of a similar façade:

- reduction of the risk of cracking and detachment, because the elements are assembled 'dry-stone' without using glues;
- an easy installation;
- maintenance and the possibility to work on every single layer;
- protection of the building from atmospheric agents;
- elimination of heat bridges;
- increase of the internal heat during winter;
- reduction of energetic transmissions;
- possibility of ventilation during the night in order to reduce the temperature of the rooms and refresh the internal still structures;
- possibility of perfect integration with solar shields;
- maximum exploitation of natural light;
- better acoustic services, through a protection system from external noises, but also noises coming from different floors of the building.

Some disadvantages can occur using this kind of façade:
- the initial investment for a double skin façade is 20-80% expensive than for a single façade
- higher cleaning costs;
- the need of more energy for production, for building and demolition, so a bigger environmental impact than a standard building;
- less volume at disposal, caused by the bigger façade;
- the necessity of a mechanical supporting unit to ventilate and refresh the rooms during summer;
- little protection from fire because smoke and fire easily spread within the hollow space dedicated to ventilation.

Closer bibliographical and web site analysis

Marco Sala, Integrazione Architettonica del Fotovoltaico, Casi studio di Edifici Pubblici in Toscana, Firenze, Alinea, 2003.

Gaetano Melzi, Dizionario di opere anonime e pseudonime di scrittori italiani o come che sia aventi relazione all'Italia, Milano: L. di G. Pirola, 1848-1859, 3 volumi

http://www.bbri.be/activefacades/new/content/1_home/en.html

Pic. 34 - Kingsdale School London.

Description of the strategy

Glasshouses are solar systems integrated in the building and are able to contribute to the heating of the rooms, within which is possible to reach good environmental comfort without using mechanical air conditioning systems, reducing in this way energetic costs.
The 'Buffer space system' constructive strategy is based on the creation of small rooms with a controlled micro-climate located in the spaces among the different blocks of the building; these buffer spaces, characterised by transparent surfaces on the cover help to reduce heat loss and keep internal rooms warmer during winter.
These characteristics make glasshouses and 'Buffer spaces' good building systems for schools, where 'cushion spaces' are very important because those spaces can be used for recreational activities and during the whole year.

Note
Within glasshouses sun radiation turns into heat because of the greenhouse effect: when a percentage of short waves sun radiation which passes through the glass reaches the objects in the room turns into long wave radiation, which can only partly flow outside and partly is absorbed as thermal radiation.

Target - Mediterranean area

In the design of this kind of glasshouses is very important to choose a south orientation, so as to exploit the sun light during winter; yet, in order to limit overheating during summer, in the areas with a Mediterranean climate is better to adopt a south-east orientation, with a maximum angular variation of 30°. During the design of these systems is also important to project external moving shading systems and doors and windows which can be easily opened in order to help ventilation and they should cover at least 50% of the glass surface. Another important and effective shading system is the use of deciduous trees, which, if placed on the west side of the glasshouse, guarantee a good shadowing during summer.

Norm Reference

Pay back period

Long

Estimate of achievable saving

30 %

Environmental quality degree of improvement

1	2	3	4	5

02.12
Glasshouses and Buffer Spaces

Pic. 35 - Harris Academy, London, UK.

✶ Closer Analysis

In order to make these systems really efficient, it is fundamental that the transparent wrapping of the glasshouses and of the 'buffer spaces' is made of monolayer or polycarbonate glasses, so as to attract more sun light on the irradiated surfaces; yet, in order to avoid heat dispersion during winter, it can be useful to use internal insulation and darkening panels which placed in front of the transparent surfaces during night increased the thermal transmittance of the transparent volume. Glasshouses and buffer spaces present particular characteristics also from an architectural point of view: being protected from atmospheric agents, they are occupied during the whole year and permit to benefit more the external and internal spaces, moreover they give shape to the morphology and aspect of the building, giving it specific architectural connotations.
In order to improve the performance of these spaces is advisable to use vegetation within the glass space, so as to contribute to control the relative temperature and humidity, improving comfort for the users; also the placement of expanses of water out of the glass surface can be considered a good strategy because they work both as reflecting surfaces able to increase the solar contribute during winter and as air control during summer.

These systems present two layouts, according to the specific seasonal period:
In winter they temper external cold air, permitting the pre-heating of the air destined to the ventilation of internal rooms.
In this way an increase of the temperature in the buffer spaces is generated and the heat is transferred in the internal rooms through their walls and through specific openings which permit the circulation of air from the hall to the rooms.
In summer the system is based on the convective disposal of the heat and on the ventilation of the rooms, starting the chimney effect. Openings on the surface, with proper dimensions, permit to remove the excessive heat helping warm upward air masses to flow out and consequently increasing the change of air; moreover air flows coming from outside increase the ventilation of internal rooms, which is also favoured by the difference of pressure between the walls facing the glasshouse and those facing outside.

Pic. 35 - GlassHouse in ICT Chamber of Commerce, Lucca, 2011. Project: Lucca Administration

Closer bibliographical and web site analysis

ZAPPONE C., La serra solare, Sistemi Editoriali, Napoli, 2008

TUCCI F., Involucro Ben Temperato, Alinea, Firenze, 2006

ENERGY RESEARCH GROUP, Clime, nature and architecture, James and James, Londra 1994

HEGGER M., FUCHS M., STARK T., ZEUMER M., Atlante della sostenibilità e della efficienza energetica degli edifici, UTET, 2008

http://www.builditsolar.com/Projects/Sunspace/sunspaces.htm

http://www.greenspec.co.uk/passive-solar-sunspaces.php

http://www.oregon.gov/ENERGY/RENEW/Solar/docs/sunspace.pdf?ga=t

Materials and construction technologies
Skylights and Solar pipes

Pic. 36 - Bailly School Complex by Mikou Design Studio

Description of the strategy

In the design of school buildings natural light is the main source of light, because not only does it help the visual comfort, but it also decreases the risk of a possible drop of the student's level of attention and it allows to reduce the energy consumption caused by the artificial lighting devices. The design of the lighting requires therefore a correct balance between functional-technologic choices and formal-architectural intentions. If a high lighting level is required in the laboratories and workshop rooms, a minimal and consistent lighting level is usually required in the classrooms. It is therefore necessary to pay attention to the quantity and quality of the light coming in to avoid direct sunlight, which during the hottest months produces air warming and can cause the dazzling of the students, instead of a diffuse light.
The use of upgrading solutions such as Skylights and Solar pipes can markedly improve the comfort level of the rooms and besides optimizing the interior light, these systems can work as an air recycling system.

Notes

L' Unified Glare Rating è un indice unificato in campo internazionale usato per la valutazione dell'abbagliamento diretto. Questo indice valuta la presenza in un ambiente di abbagliamento di tipo molesto, il suo valore dipende dalla disposizione degli apparecchi illuminanti, delle caratteristiche dell'ambiente (dimensioni, indici di riflessione) e del punto di osservazione degli operatori e oscilla con valori compresi tra 10 (nessun abbagliamento) a 30 (abbagliamento fisiologico considerevole).

Target - Mediterranean area

Natural light is usually considered an element of environmental quality, but in summer time, in the Mediterranean Area, the uncontrolled entrance of sun radiation, particularly on the walls that are exposed to South and South-West, it can have a negative effect on the indoor comfort, causing warming phenomenons. A suitable design of the windows and of the appropriate shading system can compensate for these problems and an accurate alternated placement of more skylights in the same room can contribute to the air circulation thanks to an stack effect, allowing natural ventilation and taking the heat out of the environments.

Norm Reference

UNI EN 11165:2005 – Light and Lighting – Interior Lighting- Evaluation of the dazzling according to the rating method UGR

UNI 10840:2007 – Light and Lighting – School Rooms – General Criteria for the Artificial and Natural Light

DM 18 dicembre 1975 – Norme tecniche aggiornate relative all'edilizia scolastica, ivi compresi gli indici di funzionalità didattica, edilizia ed urbanistica, art.5.2.2 e art. 5.2.5

UNI EN 15193:2007 – Energy Performance of buildings – Energy requirements for Lighting.

Pay back period

Long

Estimate of achievable saving

30 %

Environmental quality degree of improvement

1	2	3	4	5

02.13
Skylights and Solar pipes

Pic. 37 - Public Library - Casalgrande Reggio Emilia.

Pic 38 - Pimary School Belas

✶ Closer Analysis

The solar pipes are systems used to catch natural light and channel it into dark rooms that don't have access to exterior natural light.
They consist of a aluminium tube that channels the sunlight into a highly reflective light shaft that reflects the sunlight downwards to a light diffuser placed on the ceiling of the room that needs to be illuminated.
The shape and the size of the light sensor, of the light shaft and of the light diffuser have to be able to assure a suitable level of lighting for the whole year.
The light shaft dimensions change according to the area that we want to illuminate and they can have both a round and square shape.
There are systems supported by a heliostat that can follow the solar path and can optimize its position according to the angle of the incident rays and to the consumer's needs; in the school building these kind of systems can be designed so that they can catch sunbeams in winter time avoiding them to enter during the summer time.
These systems, as opposed to the traditional skylight, have the advantage of not being subject to heat loss, overheating and to be used in buildings that already exist, their low environmental visual impact, becomes a useful feature specially in the case of a retrofit intervention in historical areas.

Closer bibliographical and web site analysis

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Materials and construction technologies
Light shelves

Pic. 39 - Sidwell Friends School, Washington D.C , Kieran Timberlake

Description of the strategy

The “Light Shelves” are a day lighting system consisting of horizontal elements designed to release sunbeams into a room in a more uniform way, they shield and reflect the light so that they avoid the annoying direct radiation effects without compromising the view towards the outside. The light shelves can be inside or outside the building, they are fixed at right angles to the vertical axis of a window so that they divide it in two parts; the outer horizontal surface of the shelf is made of a reflective material that sends the incident solar radiation towards the ceiling, passing from the top side of the window and from the ceiling through a second reflection, in order to spread it in the classroom avoiding energy waste caused by artificial lighting and an improvement of the visual comfort.

Notes

These kind of systems can usually reflect sunlight in a room up to 2,5 times the distance between the floor and the top of the window, while the configuration of the room and of the ceiling height determine their position, not lower than 3 metres anyway. In terms of size the depth of the inner shelf should be equal to the height of the upper window, while the depth of the outer shelf should be equal to its distance from the work surface.
In general, the lower the height on which the light shelf is placed, the higher the dazzling and the amount of light reflected to the ceiling; an inclination of the shelves upward produces an improvement of the reflected light penetration but also a reduction of the screening effect.
On the contrary, by tilting the shelves downwards you will improve the screening effect and a reduction of the reflected light.

Target - Mediterranean area

Light shelves can find a good application in the countries with a high availability of sunlight as those in the Mediterranean Area, especially in environments that face South, while their application is not so good in those environments facing East-West or in those geographical areas where the sky is mainly cloudy. At a low latitude, the depth of the light shelves can be used to screen direct sunlight, while at a higher latitude and in those environments facing East-West, the depth of the shelf should be increased to avoid the risk of dazzling. This causes though a reduction of the quantity of natural light, with several power and thermal disadvantages.

Norm Reference

UNI EN 11165:2005 - Luce e illuminazione - Illuminazione di interni - Valutazione dell’abbagliamento molesto con il metodo UGR.

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DM 18 dicembre 1975 - Norme tecniche aggiornate relative all’edilizia scolastica, ivi compresi gli indici di funzionalità didattica, edilizia ed urbanistica, da osservarsi nella esecuzione di opere di edilizia scolastica, art 5.2.2. e art. 5.2.5.

UNI EN 15193:2007 - Energy performance of buildings - Energy requiirements for lighting.

Pay back period

Medium

Estimate of achievable saving

25 %

Environmental quality degree of improvement

1	2	3	4	5

02.14
Light shelves

Pic. 40 - Clackamas High School, Boora Architects

✶ Closer Analysis

The need to shield and in the meantime to allow the entrance of natural light in the classrooms determines the choice of type, orientation and positioning of the light shelves. The amount of entering light can be adjusted according to the geometry and surface of the shelf.
Together with the traditional systems there are light shelves that move and they are more flexible for the control and the application (adjustable according to the solar position or to the luminance of the sky), but they are more expensive than the fixed ones.
Concerning the optically processed light shelves, unlike a traditional system, they block the direct light all day long and they allow the light to reach deeper inside the room, thus allowing more energy savings than a traditional light shelves system, moreover the curvature or other regular forms allows a specific solar reflection for each specific altitude.
Also the surface texture will affect the efficiency and direction of light in the classrooms, depending on whether it is more or less opaque it will give a diffuse or specular reflection, (with the same angle as the incident one).
The ceiling is an important item in this kind of technology because the light reflects on it first and then in the room. The quality and the amount of solar penetration depend on its slope. In the case of a flat ceiling the light will be primarily reflected in the space next to the window, but ceilings with a slight slope are preferable because they allow a uniform diffusion of the light.

Pic. 41 - Clackamas High School, Boora Architects

Closer bibliographical and web site analysis

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Integration of PV Systems

Pic. 42 - David Suzuki Public School , Markham, Ontario, Canada.

Description of the strategy

The PV panel, whether it is installed in the covers, in the facades or in the big glass doors can become a decisive factor of architectural character, as an active component of the building, which can contribute to the building's energy demand through the production of renewable energy. It's clear therefore that in order to obtain a balanced integration of a photovoltaic system, both in the retrofit interventions and in the project ex-novo, it is necessary to evaluate its sizing not only as far as the electric power production is concerned but also as far as the integration with the other building components is concerned and particularly how it is integrated in the environment.
In school buildings the photovoltaic can be installed as a shielding system when there are big transparent surfaces or as a covering, partially or totally integrating it. Besides the economic and energy advantage, photovoltaic plants gain an educational valence, showing how it is possible to get electricity from renewable energy sources.

Notes
The installation of photovoltaic plants for electric power is best when there are environmental and economic favourable conditions (contributions, incentives, etc.). At the moment an photovoltaic plants usually lasts for about twenty to thirty years, while it is estimated that the installation cost of an PV system can be written off in ten years time.

Target - Mediterranean area

In the Mediterranean Area the PV system can be integrated in the building as a total or partial shielding system, and can be used not only as a system that produces energy but also as a technologic solution to overshadow inner rooms, reducing their heat in summer months, when the direct solar radiation is the main cause of consumers discomfort. The possibility to check the dimension and the colour of the cells that constitute the panel allows the control of light radiation and to obtain very nice inner lighting effect.

Norm Reference

DPR 59/09 - Regolamento di attuazione dell'articolo 4, comma 1, lettere a) e b), del decreto legislativo 19 agosto 2005, n. 192, concernente attuazione della direttiva 2002/91/CE sul rendimento energetico in edilizia.

D.Lgs. n. 28/2011 - Attuazione della direttiva 2009/28/CE sulla promozione dell'uso dell'energia da fonti rinnovabili, recante modifica e successiva abrogazione delle direttive 2001/77/CE e 2003/30/CE.

D.M. 05/05/2011 - Incentivazione della produzione di energia elettrica da impianti solari fotovoltaici.

Pay back period

Medium

Estimate of achievable saving

If there are economic incentives the cost of the PV system is amortized in eight years

Environmental quality degree of improvement

1 2 3 4 5

03.01
Integration of PV Systems

Pic. 43 - Bresol School, St.Celoni, Catalogna, Spagna.

Pic. 44 - Kei Wai primary school

Closer Analysis

A PV System allows the conversion of electromagnetic power coming from the sun into electric power thanks to the PV effects and it's based on the properties of semiconductor materials.
The main device of photovoltaic technology that is able to convert solar power is the cell, made of a semiconductor material with a reduced thickness to whom electric contacts are connected.
The semiconductor that is used the most is the silicon that can be of different kinds: polycrystalline, monocristalline or amorphous. When the cell is exposed to sun light it is possible to create an electric charge and produce energy power in direct current that will be turned by the inverter into alternating current that can be used in normal electrical system.
The relation between the electric power that the consumer receives and the available radiation is called performance and constitutes the benchmark to estimate the efficiency of the PV rcircles. For a correct use of the PV panels it is necessary and essential that they are placed and directed facing South, there shouldn't be any obstacle that creates shading and the inclination of the panels should be between 25° and 35° (according to the latitude).

Closer bibliographical and web site analysis

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Energy produced by renewable sources
Solar thermal panels

Pic. 45 -Secondary School Vignola, 2010. Project: MSA, arch. MArco Sala

Description of the strategy

A thermal solar system uses the energy contained in solar radiation to heat the water up to 60°- 80° such a system, when combined with solar thermal panels can contribute to winter heating. In school buildings the usual domestic hot water consumption is reduced to a few litres a day and during the summer months, when the performance of solar panels is higher, schools are closed. In these conditions the use of solar collector is not convenient.
The utility of installing solar panels when the heating system is the one using radiant floor or roofs, is to be carefully assessed when the school complex includes gyms or other sports facilities that consume high amounts of hot water. Solar panels can be installed in both flat and sloped roofs, terraces, facades, but it is recommended the full architectural integration in case of renovation interventions or project ex-novo.

Notes

Being the solar source discontinuous and unpredictable, it is necessary to equip the system with an additional traditional heating system (condensing boiler).
Thermal solar system are extremely reliable (they usually last for at least 20 years) and also their maintenance is quite easy.
About the production of hot water, solar systems allow to cover usually the 60-70% of the thermal demand of the consumers in a year, with some high pitches of 100% during the summer months. The heating of rooms can assure an efficiency of 30-40%.

Target - Mediterranean area

At Mediterranean latitudes the maximum efficiency of a solar heating system is achieved by orienting the collectors South, tilting them by 30° from the horizontal surface.
As far as school building is concerned, being the load higher in winter time, it is preferable to increase the inclination of 10-15° with respect to the latitude of the place. If the solar heating system is also suitable for environments heating, the inclination of the collectors can be higher than the one above in order to favour winter production of thermal energy for the heating.

Norm Reference

DM 24 Aprile 2001 - Individuazione degli obiettivi quantitativi nazionali di risparmio energetico e sviluppo delle fonti rinnovabili di cui all'art. 16, comma 4, del decreto legislativo 23 maggio 2000, n. 164.

D.Lgs. n. 192/2005 - Attuazione della Direttiva 2002/91/CE relativa al rendimento energetico nell'edilizia.

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Pay back period

Long

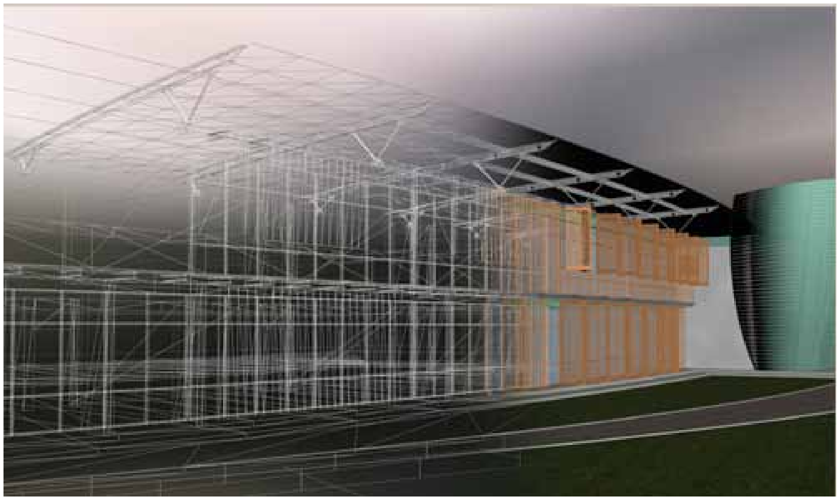
Estimate of achievable saving

50 %

Environmental quality degree of improvement

1	2	3	4	5

03.02
Solar thermal panels



Pic. 46 - econdary School Vignola, 2010. Project: MSA, arch. MArco Sala

✶ Closer Analysis

The hot water requirements according to which it is necessary to size the surface of the solar thermal panels of course changes depending on whether the system produces only hot water or it is a combined one.
The energy production of a system goes from 1,5 to 3,5 kWh/sq a day of the surface of the glass solar collector piano, respectively in winter and summer at our latitudes and with a clear sky.
There are three main types of solar collectors:
- Flat panels
- Vacuum tube
- Concentrating solar collector

The flat solar collectors are the most common ones. They can be:
- Glass panel: they are basically made of a glass cover, an insulated absorbing plate in the lower part and on its sides and they are kept in a plastic or metal chest.
-Uncovered (not with glass): they are usually made of a plastic material and directly exposed to sun light. Their use is usually limited to the heating of swimming pools water.

The concentrating solar collectors are concave, which are designed to optimize the concentration of solar energy in a specific point (focus). They are efficient only in with direct sun light because they have to follow the movements of the sun. This kind of collector, being it able to reach high temperatures, is a logical choice for solar power generator or for ovens at very high temperatures (over 400/500°C).
A solar thermal system is basically composed of solar collectors, a storage tank and a control system.
The solar thermal panels are constituted by a capturing plate which, thanks to its geometry and the properties of its surface absorbs solar radiation and converts it into heat (photo thermal conversion) transferring it to a heat transfer fluid that circulates inside the absorbing plate; the solar energy captured and transported by the fluid can be stored or put into circle directly in the system so that it can be directly used for heating and/or space cooling. The accumulation tank collects the fluid supplied by the collectors, integrated with the conventional system as to improve the efficiency of the traditional boiler.
As for the economic evaluation of a solar thermal system it is important to think about a long-term perspective, because if the system is realized with the help of tax incentives, its payback period will be of a couple of years, if it's realized with with private funds, its payback time can exceed six years time.
In order to size properly the surface of solar thermal panels needed to meet the consumers requests, it is necessary to choose the type of solar collectors taking into consideration some information such as domestic hot water requirements, orientation and inclination of the surfaces available for the installation, climate and the presence of any shading factors.

Closer bibliographical and web site analysis

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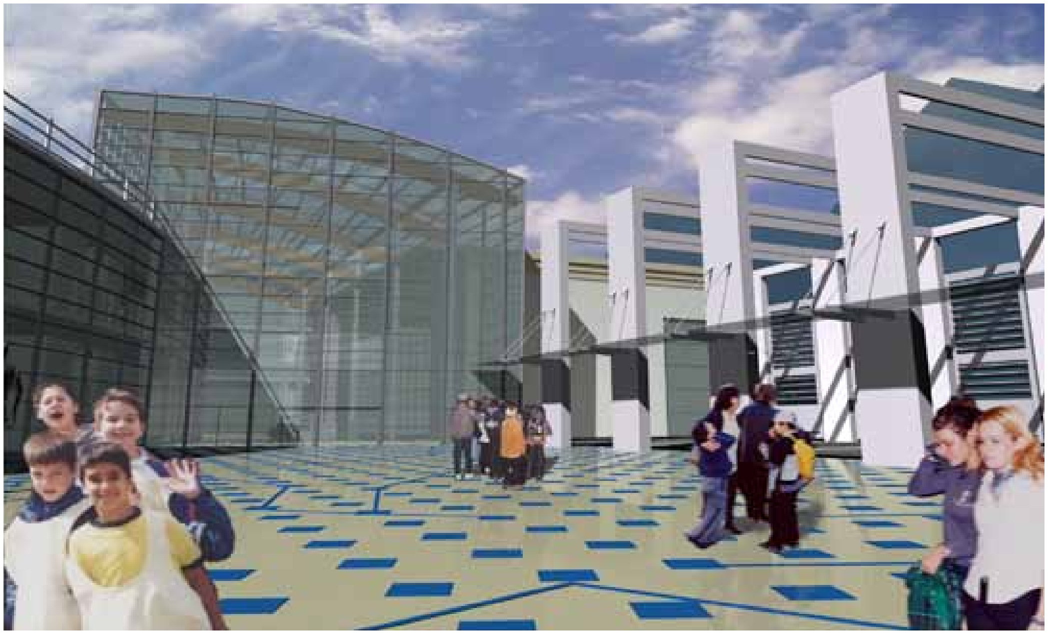
Energy produced by renewable sources
Geothermal System



Pic. 47 - Primary School Pistoia, Italy, 2006. Project: MSA, arch. Marco Sala

Description of the strategy

The temperature of the ground, only a few meters deep, is constant during the whole year, in the winter months the ground temperature is relatively warmer than outside air, while in summer months the temperature is lower than the one of the air. The heating and cooling with geothermal heat pumps take advantage of this condition allowing significant energy savings, both in hot and cold months.
Using as a carrier the water inside the geothermal pump inserted into the ground and using a heat pump, the heat extracted turns into a temperature difference, useful for heating during winter and cooling during summer.
The heat pump can also be powered by electricity; in this case it can be connected to a PV panel system, making the conditioning energy system self-sufficient. There is also the possibility to combine the geothermal system with a solar heating system in order to ensure a constant production of hot water.

Notes

In case of retrofit interventions, the convenience and feasibility of a geothermal system are to be analyzed carefully. The availability of space for the building site and for the installation of the pumps needs to be assessed. The installation of a geothermal system is a convenient choice for all existing buildings that use fossil fuel fired boilers, while in case of a the building which is equipped with a natural gas boiler, one must carefully evaluate the cost /benefits.
As for the estimation of an average life of a system, we can say that generally the geothermal heat pumps have a duration of at least 15-20 years, while the geothermal pumps can be operative for several dozens of years without any maintenance requirements.

Target - Mediterranean area

The main advantage that we can have from geothermal systems derives from the opportunity to produce not only hot water for the heating and sanitary use, but also cold water for summer cooling, enclosing in only one system the same functions that are usually assigned to boilers and air conditioners, making geothermal system a good alternative to traditional systems.
If properly sized, a geothermal system can heat and/or cool autonomously a whole building (monovalent system). A very interesting opportunity offered by geothermal technologies is the possibility of combining it with other systems (bivalent system) like for example the solar thermal panel and the condensing boiler, good solution for school buildings in order to improve heat gain produced by renewable sources during the cold season.

Norm Reference

Pay back period

Medium

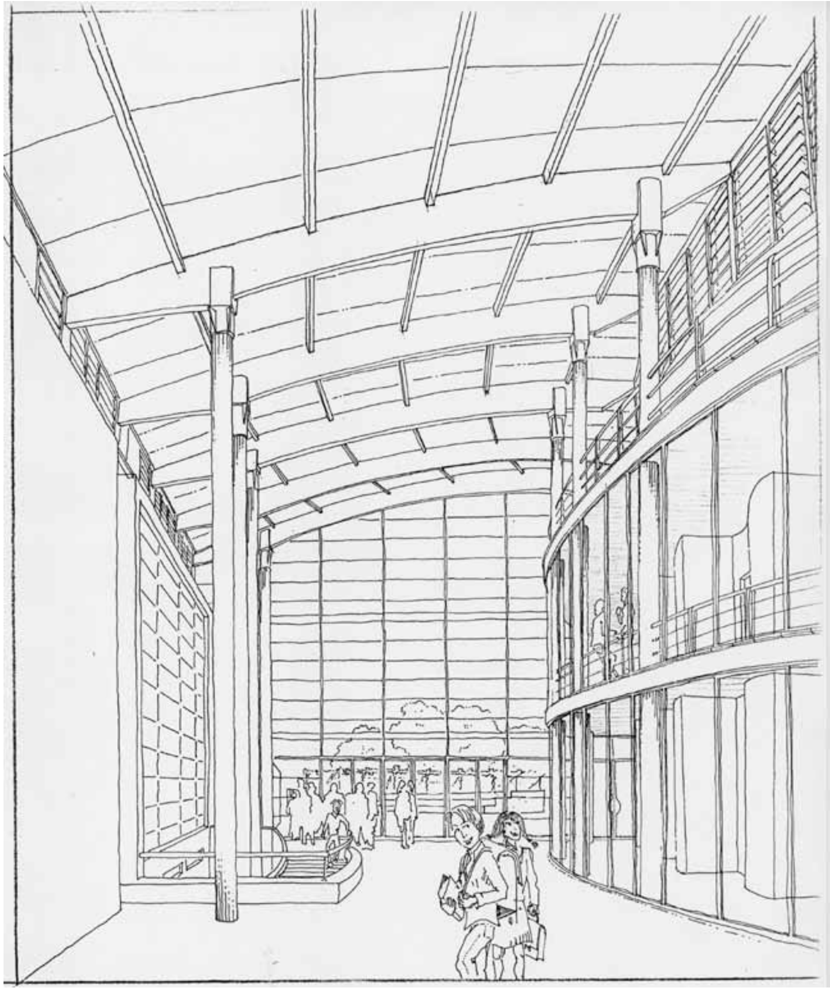
Estimate of achievable saving

45 %

Environmental quality degree of improvement

1	2	3	4	5

03.04
Geothermal System



Pic. 48- Sunspace in Primary School Pistoia, Italy, 2006. Project: MSA, arch. Marco Sala

✶ Closer Analysis

Among the most common solutions for a geothermal power system, the "vertical loops" one is the only one that can properly be called "geometric" because it exploits the endogenous heat of the earth, which at 15-20 metres deep is not affected by changes from the outside climate, using soil temperature which is constant throughout the year and that increases the deeper you go.

The "horizontal loops" solution instead exploits the heat present in the shallow soil. This technological solution can't be properly defined as geometric, since it depends on the solar radiation accumulated in the surface layers of the soil and not only on the endogenous heat from the subsoil. In this case the collectors, made of plastic material, are buried horizontally at about 1-2 metres deep and act as heat exchangers, exploiting the relative stability of the temperatures already at these depths, usually included between 2-20°C. Compared to systems that use vertical probe geometry, the solution "horizontal loops", while guaranteeing good performance, it allows lower efficiency especially in cold months.

Among the geothermal conditioning systems we must remember those that use cooling dissipative through the possibility of circulating air taken from the outside, through pipes underground, which transfer heat to the ground, cooling it before entering the environment. The air movement can be achieved through controlled mechanical or natural ventilation.

In his book dedicated to natural ventilation, Mario Grosso reminds us that there are two types of geothermal for cooling systems:

-single duct, suitable for residential buildings;

-with more ducts placed parallel to the ground and suitable for non residential buildings, with high air flow, like school buildings.

It is not possible to define precisely the contribution that a cooling geothermal system can provide to the needs of a school building, as they are not yet available reliable calculating models, which take into account the complex dynamic phenomena in question. In any case it is possible to achieve reductions, on the annual cooling needs, ranging from 20% to 80%.

Closer bibliographical and web site analysis

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Energy produced by renewable sources
Cogeneration (Combined heat and power, CHP)

Pic. 50 Solarhouse in Secondary School in Fano, Italy, 2008. Arch. Chiara Zandri

Description of the strategy

The term Cogeneeration means the simultaneous production of electricity and thermal energy (combined heat and electricity - CHP) coming from a single source of energy.
In contrast to a traditional system, cogeeration is based on the recovery of the heat generated during the production of electrical energy, which instead is usually dispersed in the environment, to produce thermal energy for space heating, thus saving the fuel that would be necessary for the production of that heat.
A CHP system can be used efficiently in all buildings that use both electricity and thermal energy, allowing, compared to separate energy production, a saving that can be estimated around 35/40%.
The school buildings have a low thermal load factor, they remain closed in the summer, on Sundays and often on Saturday, while they are active only for a few hours a day, in these conditions, the use of cogeneration unit is not convenient. If, however, there were gyms and swimming pools open to the public even after school time, or laboratories that require large amounts of energy, such as technical colleges, the system could be used within the terms of economic feasibility for this type of users.

Target - Mediterranean area

The cogeneration systems applied to school buildings are affected by the fact that the energy needs of users exists primarily in a limited period of the year, when it is necessary to heat the buildings. In summer however, the system dissipates the heat produced customers would require cooling energy to allow the cooling of buildings. A solution to overcome this problem is the “trigeneration”, a system capable of simultaneously producing electricity, heat and cooling.

Norm Reference

D.M. 24/10/2005 - Aggiornamento delle direttive per l’incentivazione dell’energia elettrica prodotta da fonti rinnovabili.

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D.M. 4 agosto 2011 - Misure per la promozione della cogenerazione - Integrazioni al Dlgs 20/2007.

D.M. 5 settembre 2011 - Definizione del nuovo regime di sostegno per la cogenerazione ad alto rendimento.

Pay back period

Medium

Estimate of achievable saving

40%

Environmental quality degree of improvement

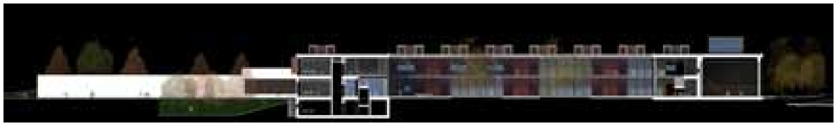
1	2	3	4	5

03.05
Cogeneration (Combined heat and power, CHP)

Pic. 51 - Primary school in Albino, Italy 2008. Project : arch. Leonardo Pugin

✶ Closer Analysis

Combined, Cooling, Heating and Power), which combines, in addition to the combined production of electricity and thermal energy, also the function of air conditioning and cooling , also recovering energy from exhaust fumes and heat otherwise lost.
The cooling is produced thanks to the use of the normal refrigerating cycle capable of transforming thermal energy into cooling energy based on the processing status of the cooling fluid (water) in combination with the substance used as absorbent (lithium bromide). The use of such a system can lead to a 60% energy saving.
They have recently put on the market CCHP systems, fed by mixtures of methane and hydrogen. These systems consist of an electrolyser served by a photovoltaic system. The system allows the photo-electrolysis of water for the production of hydrogen which will subsequently enrich the methane necessary to feed a CHP group. If used in a school complex with sports facilities, these technological systems can be used for combined production of thermal energy for heating swimming pools and electricity for sports fields and the school building. All of this can happen reducing a lot the emission of CO_2, as the methane-hydrogen mixture has a low carbon content, unlike the hydrocarbons.
A CHP system is usually constituted by a system prime mover (steam turbine, gas turbine or internal combustion engine), by an electric generator driven by the installation engine that produces electricity, and heat exchangers.
There are on the market even small systems, with an electrical capacity of less than 1 MW and average size ones with a capacity of less than 50KW. In both cases the systems are manufactured with internal combustion engines, micro gas turbines or Stirling cycle engines. The microcogeneration is used to produce heat, while the small scale also ensures a good production of electrical energy.
CHP systems arise usually close to thermal loads since, due to the high transmission losses, it is not technically or economically advantageous to transmit the heat over long distances. This need, however, clashes with the tendency of placing thermoelectrically system for energy production far from towns, thus requiring that the CHP systems installed close to towns are mostly limited in size.
Another condition that allows a CHP plant be exploited in a proper way is that there must be a simultaneous demand for heat and power. A CHP plant is usually capable of providing heat and electricity simultaneously, for this reason the CHP plants often give the energy produced in excess to the national network, making the system work so that it adapts the requirements of consumers thermal energy. Should the CHP system be insufficient to satisfy all the thermal requirements, it can be integrated with a traditional heating system.



Pic. 51 - Primary school in Albino, Italy 2008. Project : arch. Leonardo Pugin

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Control systems for energy saving
Light control

Pic. 52 - Primary school in Albino, Italy 2008. Project : arch. Leonardo Pugin

Description of the strategy

Inside a school building light design (natural and artificial), is an important factor because it affects the energy consumption due to heating, cooling and artificial lighting,as well as the sight comfort. A good lighting design of the classroom aims to create a suitable learning environment, social interaction, as well as to ensure the mental well-being of users. The lighting arrangements to be adopted must take into consideration the correct proportion between direct and indirect light, vertical lighting, the glare, the color of light that affects the psychological state.
Lighting design should take into account variables such as: the environment, the functional purpose, the percentage of natural light. For this reason in schools the following conditions are crucial: the adjustment of lighting devices with light sensors, the possibility to automatically adjust the screenings, detection devices for presence/absence, which allow you to turn off the lights when the classroom is empty. The majority of school buildings have a system of artificial lighting consisting of long fluorescent tubes placed on the ceiling that provide a type of light fairly uniform.
However, in many schools, especially in offices and bathrooms, there are still incandescent lamps with tungsten filament. Lamps are inefficient and not very durable and over time they emit less and less light, while consuming the same amount of energy.
The consequences of these types of systems are eye fatigue, dryness of the cornea, photophobia, migraine, myopia and reduced attention spans.

Target - Mediterranean area

Reduction of energy consumption
-Avoid to overheat the classrooms
-Ensure consumers visual comfort
.Day light integration
-Achieve the required level of light

Norm Reference

UNI 10840 - Dispositivi di regolazione per adattare l'illuminazione all'utilizzo di materiale audiovisivo e sistemi d'illuminazione dedicati per le lavagne, al fine di garantire chiarezza.

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UNI EN 13363-2:2006 – Dispositivi di protezione solare in combinazione con vetrate – Calcolo della trasmittanza solare e luminosa, parte 2

UNI 10840:2007 – Luce e illuminazione – Locali scolastici – Criteri generali per l'illuminazione naturale ed artificiale. Prospetto 2.

Pay back period

Medium

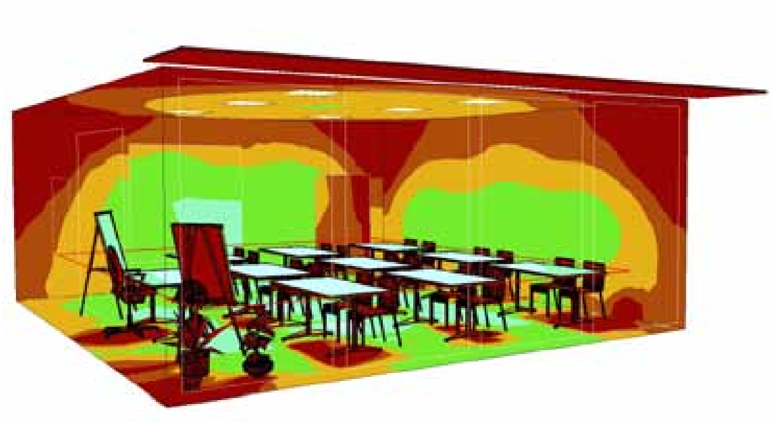
Estimate of achievable saving

35 %

Environmental quality degree of improvement

1 2 3 4 5

04.01
Light control



Pic. 53 - Natural Lighting analysis with software RELUX

Closer Analysis

It is necessary to install in the classrooms an automatic light system, using higher frequency fluorescent linear lamps endowed with adjustable chargers connected to photosensors which will have to be placed in a suitable way in the classrooms and set for the prearranged average luminance.
By adjusting the luminous flux of lamps, according to the set value of illuminance, the devices placed near the windows on a day of light will emit a lower light output than the remaining lamps installed in the rooms, thus ensuring both the level of illumination required and the energy saving.
The adjustment of the luminous flux of fluorescent lamps can be made either automatically, through the application of a photosensor connected to the electronic trasformer, or manually through the application of an empowerment.
The power absorbed by the fluorescent lamps fed by an electronic ballast is proportional to the luminous flux emitted (10% - 100%). In alternative to the automatic lighting lamps with high frequency is possible to feed the row of lamps placed close to the windows with a control circuit separate from the other lamps of the classroom, so as to realize ignition separate.
It is necessary to place the lighting devices in order to reduce the reflectance percentage of the internal surfaces of the room, which must not be less than 90% for the ceiling, 60% for the walls and 20% for the floor. The problem of reflection is partly solved by using luminaries with asymmetric distribution.
In the design of the lighting the fundamental quantity that has to be taken into account is the illumination En, which in schools is related to the height of the worktop (desks, chairs, benches laboratories, etc.), generally considered at 0.85 m above the floor. You get a good uniform light, which is important for a good detail perception and to work safely and without any eye strain, when the relation between the minimal lighting Emin and medium lighting Em is close to 1. In school environments the uniformity relation doesn't have to be less than 0,8 on the surface of a worktop. A good system to obtain a good uniformity is the one where you place the lightning devices on equidistant rows and with regular breaks, always verifying anyway the relation between the value of the maximum spacing dx between the devices with height hu (hu is the height between the worktop and the assembly of the lightning devices), this relation is given by the constructor of the devices, or verifying the isolux chart or the luminance value obtained by software of lighting calculation. In the classrooms the level of light varies from 300lx (suitable for young students and general activities) to 500 lx (suitable for adult students and for more complex activities). It is also important to check the colour rendering which affects not only sight but also psychologic comfort. In school environments it is recommended to have a colour rendering Ra which corresponds to 1B, with a value included between 80< Ra <90 and with a colour shade W (warm) White – Warm and I (intermediate) White – Neutral.

Closer bibliographical and web site analysis

Palladino Pietro, Lezioni di Illuminotecnica, Tecniche Nuove, Milano, 2002

http://www.roero-illuminazione.it/attachments/4034_Illuminazione%20per%20ambienti%20scolastici%20by%20Thorn.pdf

http://www.taed.unifi.it/fisica_tecnica/dispense/fond_luce.pdf

Control systems for energy saving
Control systems for energy saving

Pic. 54 - Istituto Don Milani, Brescia, illuminazione interna con sensori di accensione e spegnimento automatico

Description of the strategy

In order to control and adjust the luminous flux on school premises to prevent possible phenomena of underexposure and overexposure, and simultaneously reduce energy consumption, it is important to use in those rooms used for teaching a system of intelligent control of the lights, composed of photosensors able to modulate (dimming) the light intensity emitted from lamps of each room when the contribution of natural light varies.
To control the lighting in continued use environments as hallways, stairs, toilets and changing rooms, you can associate light sensors with presence sensors, that automatically adjust the light depending on whether there is someone in the room or not, allowing optimization of power consumption.

Notes
Compared to manually controlled lighting systems the installation of photosensors requires an certainly higher initial outlay and a particular attention to the light design project. These systems, however, allow a considerable saving of energy and an improvement of the conditions of comfort of users and teachers, thus reducing the conditions of visual fatigue and loss of concentration.

Target - Mediterranean area

The installation of light sensors may be accompanied by the adoption of systems that regulate the luminous flux which itself can control shading devices, orienting the outer plates and the internal curtains to the desired position.
Through the control of the lighting system there can therefore be an increase of the installation of BMS that allow to control and adjust not only the light component of solar radiation, but also and above all the thermal component avoiding overheating phenomena in the intermediate seasons.

Norm Reference

Pay back period

Medium

Estimate of achievable saving

35%

Environmental quality degree of improvement

1	2	3	4	5

04.02
Control systems for energy saving

Pic. 55 - Halde di Chur School

High-Efficiency Lighting	Rebuilding Application	Replace for	Energy Saving	Other Benefits
Dedicated compact fluorescent flouters (recessed, hanging, surface mounted)	Offices, open spaces, wc, hallways, conference rooms and outdoor lighting	40 watt to 100 watt incandescent light bulbs	66% to 75 % for incandescent light bulb replaced	Fewer bulb replacements and less heat waste
High-efficiency fluorescent lamps with electronic ballast	Office, service space, basements and garages.	Standard 34 watt to 40 watt fluorescent lamps with magnetic ballast	20% to 30% for lam and magnetic ballast replaced	Higher colour rendition and less noise
Automatic controls-motion & photo sensor	Outdoor lighting	Manual switches and timers	50% for motion sensors. 20% for photo sensors	Increased safety, security, and convenience
Sensor	Office	Switches	Bulb replaced	Replacement

Pic. 56 - Halde di Chur School

Closer Analysis

You can buy presence sensors to detect proximity, movement and heat, such instruments are generally able to control surfaces that do not exceed 50-60 mq, that's why they are particularly suited to sanitary facilities.
Another type of sensors are those called "contact sensors", which suspend the introduction of air from the forced ventilation system when you open the windows and CO_2 sensors, suitable to regulate the flow of the primary ventilation.

Closer bibliographical and web site analysis

ENEA-FIRE (a cura di) guida per il contenimento della spesa enrgetica nelle scuole - Centro Ricerche Casaccia

www.enea.it

www.fire-italia.it

Control systems for energy saving
Systems to reduce potable water use

Pic. 57 - Gemeinde Megger Primary School, Losanna, Swiss

Description of the strategy

In order to reduce potable water use for irrigation and domestic purposes, school buildings shall be designed and completed providing all taps and possible showers with water saving devices, as well as water saving toilets. It is also recommended to use rainwater collected from building roofing to irrigate the reserved green areas, to wash paved areas and to fill cisterns; the advantage in adopting these systems is increased in case sports halls and swimming pools are used not only for school purposes.

Notes
New buildings with a surface of reserved green area wider than 50 square metres shall be equipped with a rainwater tank, whose volume shall be calculated considering annual water consumption for irrigation, potential annual rainwater collection, annual rainfall, flow coefficient and filter efficiency.

Target - Mediterranean area

Technological water saving solutions are essential in the Mediterranean area in order to avoid potable water consumption when not necessary. Systems such as constructed wetlands and/or natural pools become elements of urban design with a benefit of outdoor climate, especially in summer months, when they help to cool air temperature. Purified water can be reused to irrigate reserved green areas of school buildings, ensuring the greening also when school activities are suspended.

Norm Reference

D.Lgs. 11/5/99 n. 152 - Disposizioni sulla tutela delle acque dall'inquinamento e recepimento della direttiva

91/271/CEE concernente il trattamento delle acque reflue urbane e della direttiva 91/676/CEE relativa alla protezione delle acque dall'inquinamento provocato dai nitrati provenienti da fonti agricole.

Legge 5 gennaio 1994, n. 36 - Disposizione in materia di risorse idiriche.

Legge 9 gennaio 1991, n.10 - Norme per l'attuazione del Piano energetico nazionale in materia di uso razionale dell'energia, di risparmio energetico e di sviluppo delle fonti rinnovabili di energia.

Pay back period

Medium

Estimate of achievable saving

30%

Environmental quality degree of improvement

1	2	3	4	5

04.03
Systems to reduce potable water use

Pic. 58 - Gemeinde Megger Primary School, Losanna, Swiss

Closer Analysis

Roof coverings shall be provided with waterproof valley gutters in order to collect rainwater in the downspout and in the collection system; to fulfil this requirement there should be a system for rainwater collection and filtration, as well as a water supply and distribution net for the same waters (dual function) inside and outside the building.
More precisely, a system to collect and recycle rainwater is made of:
- a roof covering without noxious substances,
- waterproof trunks for collection and drainage, in appropriate dimensions,
- a water filtration system for the first rain (5 mm for the first 15 min.),
- an inspection pit with automatic filtration system,
- an inspection collector tank, preferably inground,
- a zero discharge system connected with the main water supply net,
- some valves and an outlet pipeline connected with the rainwater collection system to drain possible exceeding water,
- an appropriate pumping and distribution system to supply water for users consumption,
- possible pipe of immission in the dual net of public use.

If possible it is advisable to consider a natural depuration system, like wetlands, where water depuration is guaranteed by the use of marine plants, which immersed in the water or in a humid substrate digest the polluted substances. Recently these systems have been developed as appendage to "natural pools", that is a natural body of bathwaters. If used in a school context natural pools can provide a study function for students, having the possibility to evaluate directly the potential offered by this technology.
Tap aerators or flow minimisers are devices which are used to reduce the flow of water from taps; these systems are formed by a spiral device which increases water speed giving a circular movement and a net system mixing air and water, for a whirling and quicker jet.
There are also other devices available for sale, producing a laminar flow instead of an aerated stream. On equal comfort laminar flow types provide high efficiency water saving.
In general these systems can reduce water use up to 50%.
As to reduce water consumption for flush toilets, cisterns shall be provided with a manual device to regulate the flush, offering at least two different flush volumes.

Closer bibliographical and web site analysis

ENEA-FIRE (a cura di) guida per il contenimento della spesa enrgetica nelle scuole - Centro Ricerche Casaccia

Cesarano A., Bellia L., Fanchiotti A., Sibilio S., Elementi di illuminazione naturale,1996

Rogora A. , Luce naturale e progetto, Rimini, Maggiore Editore, 1997

www.enea.it

www.fire-italia.it

04 Control systems for energy saving
04.04 Building automation systems

Pic. 59- Ponzano- Treviso Elementary school
System building automation with classrooms temperature control and supervision, gym and technical room.

Description of the strategy

The building automation systems, not as the traditional ones, are born as a single entity, which with a remote control system, allows the building's different devices to communicate and interact between them, this gives a considerable economic saving on the electronic system management and it guarantees a constant and major comfort conditions for the users; In fact an automation system is able to handle all the different types of facilities, monitoring and activating the linked devices in relation to sensors, which detect the environmental characteristics and adjusting the behaviour of the building.

Notes

High efficiency building control system are named " Building Energy management System-BEMS "- the BEMS scheme is composed by a principal net and different subnets which receive output and send information to the principal computer; this structure enables the identification of each system with an IP address, allowing the monitoring in a remote way.

Target - Mediterranean area

The building automation systems in the Mediterranean area guarantee to optimize the building's performances during summer time by means of a simultaneous monitoring of: shading device, illumination system, conditioning system; transforming the building in an active system which interacts with the outside environment. The external and internal humidity temperature sensors, luminosity permits the adjusting of the indoor comfort even with an absence of a prompt users management. The possibility to operate the building and the conditioning system remotely guarantees considerable energy savings, especially in public buildings where users are scarcely educated in means of operating in a sustainable way.

Norm Reference

EN 50090-2-1:1996 - Home and building Electronic System (HBES). System overview.

EN 50090-3-1:1996 - Home and building Electronic System (HBES). Aspects of applic.

Pay back period

Medium

Estimate of achievable saving

35%

Environmental quality degree of improvement

1	2	3	4	5

04.04
Building automation systems

Pic. 60- Piobesi Torinese Elementary School, Archiloco Studio Associato
the use of photovoltaic and solar Thermic panels, geothermic and green roof, natural ventilation chimneys low emission glass, permits the school to have a usage of 3,6 kwh/mc/year.

Pic. 61 - Piobesi Torinese Elementary School, Archiloco Studio Associato

Closer Analysis

A building automation system can manage and check the internal and external illumination system, the clocks and the school bells, the possible energy generator system, the central heating and the air conditioning, the managed mechanical ventilation systems and the shading system, the automatic opening and closing of doors and windows, and also the verification of the security conditions, providing reports on the activities of all the devices, visualizing the conditions and possible faults, avoiding wastes due to wrong resource management.
The illumination control is one of the most fundamental functions to guarantee a high energy saving: the logic provides that the examination is acquired by a movement sensor and by a luminosity sensor that in case of an external luminosity conditions (clouds, sun etc.)change, keeps inside the classrooms the exact level of light decided during the setting, configuring a scenery in which also the central heating and conditioning systems can follow the same rules.
In order to guarantee an energy saving, also the system of automatic doors and windows opening and closing has a fundamental role, limiting a direct entrance of external air and so decreasing loss of heat while the central heating is functioning. The BMS systems besides giving an economic saving it also provides a better comfort in the transit premises, as corridors and lobbies, reducing the temperature difference between these and the classrooms.

Closer bibliographical and web site analysis

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