Vilnius Gediminas Technical University
Faculty of Architecture
Department of Urban Design

Bioclimatic Principles in Architectural Design

A Way to Better Buildings

Arfu-13
Vilnius
2014

Contents

Foreword

The Academic Book named by its authors “Bioclimatic Principles in Architectural Design: a Way to Better Buildings” focuses on one of the most important aspects of sustainable urbanism and architectural design. This original research report is Volume 5 of annual research publication drafted by the team of students of Architecture at Vilnius Gediminas Technical University. It continues the tradition of the Design Studio project “Recreation Complex in Natural Environment” to collect, analyze and present individual research topic in a comprehensive publication and is performed by the students of Arfu-13 group at the Department of Urban Design at the Fall Term of 2014.

We strongly believe that the method of „learning through design“ brings new understanding, skills and professional capabilities for planning and designing recreational spaces and buildings of the most diverse function, structure and architecture in natural and rural sites of Lithuania. The group of students and their tutors had a pleasure of going through theory and practice of Bioclimatic Principles in Architectural Design as much as it concerns quality of for the environment and functional benefits for its users. This year’s series Vol. 5 “Bioclimatic Principles in Architectural Design: a Way to Better Buildings” continues the department’s tradition as it is produced along with the design studio project. The previous volumes of the book focused on other topics of recreational architecture and urbanism: “Sustainable Water Management” 2013, “Sustainable Design in Architecture” 2012, “Environment Elements and Details in Recreation” 2011 and “Sauna in Recreation” 2010.

The topic of Bioclimatic Principles in Architectural Design is analyzed in these chapters: Solar radiation control; Heat – cold control; Managing internal gains, Providing natural ventilation and geopathology, all seen as the way towards better buildings in sustainable and healthy urban environment. The collected, reviewed and designed material with its texts, references and numerous figures is a perfect study resource for students, researchers and many of the senior colleagues as well as for the wider public. All those concerned in sustainable urbanism and Bioclimatic Design will find a reliable and professional roadmap that will bring more understanding for making our buildings more comfortable and pleasant to use as well as easy to build and maintain.

Four working groups of students have generated the presented Chapters of this Book. The study program of Architecture at VGTU will cover more and more aspects of green urbanism and sustainable design in the next years so this book is a high step forward made by the second-year scholars in architecture. We all strongly believe that this result will certainly build up their professional career and shape personal life-style towards the highest quality and efficiency required by the society. This Book is the must reading for senior students in bachelor and master studies of Architecture, Urbanism, Landscape and related study fields.

The material presented herein is a peer-reviewed and co-edited by the Editorial Board comprised of all representatives of the students working groups. Contents of the book are based on international experience of Bioclimatic Design as this topic in Lithuania is still at its roots. The book reveals multiple methods and tools that could be used in the projects of the most different nature. It helps to translate the ideas of Bioclimatic Design from theory of books to practice of urban and architectural design.

The Vol. 5 as well as the previous volumes of the Book is also available for its readers on the website of the Department of Urban Design Vilnius Gediminas Technical University at http://ar.vgtu.lt/fakultetai/padaliniai/urbanistikos-katedra/kita-informacija/52098

The authors will appreciate all comments and proposal from the interested readers on the topic of Bioclimatic Principles in Architectural Design that will help to improve the skills of the authors who created in this Book.

Prof PhD Gintaras Stauskis

Tutor and supervisor

MEANING OF GEOPATHOLOGY IN ARCHITECTURE

Geopathology is a science that deals with the study of pathological (harmful and nauseating) energy emitted by the earth that interferes with the proper functioning of the metabolism of the cells of our body. Geopathicstress occurs mainly from natural sources, but may be caused, so the devices and electromagnetic applications such as mobile phones, computers, power lines, etc.

The term geopathology derived from two words: geo (earth) and pathology (illness) is the study of the influences that the energies of the earth may have about life in general (plant, animal, human), and the most appropriate means to restore places where these energies were discordant. It combines the knowledge and experience gained from many recognized science (geology, physics, biology, architecture, etc.), and not yet recognized (dowsing, Dowsing, etc.).

The Earth, like all living beings in the universe, a physical body and an energy that can recognize specific energy pathways and centers, comparable to those found in humans (ex. The energy centers or chakras). As the nerve currents start from the brain to reach the farthest points of the body, so that the telluric currents, which arose from the different, nerve centers of the world, through it giving it life.

Stages of physical reactions and health problems typical

The reaction of a person depends on the intensity of the situation geopathic, as well as the amount of time spent there. Reactions starting with sleep disturbances, lack of concentration, a constant state of fatigue, allergies, migraines, back pain, etc. Under continued stress, a person may experience more severe conditions such as high blood pressure, diabetes, asthma and chronic diseases of the skin. Consequently, for a long period of time, with the immune system seriously compromised, serious diseases such as cancer can occur.

Historic development of ideas in geopathology

Before you build a building, the architects of antiquity, carefully controlled with the soil to prevent it were to create zones unhealthy for the future inhabitants. They were well aware of the energies of the earth, the Chinese; in fact, never built on some land lines they called "dragon veins". Currently, to detect the existence of anomalies in the telluric radiation, can be used for electronic instruments, such as the geomagnetometro and detectors of ionizing particles.

In 1929, the German aristocrat **Gustav Freiherr von Pohl**began an experiment in the small town of Vilbisburg. He dowsed the entire city for the energies of the earth harmful underground streams and fault lines in the earth. Every day was accompanied by a police officer to ensure that he would not talk to anyone.After a week he had finished his work and the judge of the city from its hand-drawn map with a list of all the homes of cancer patients over the past 10 years.He found a correlation of 100%.The experiment was repeated several times over the following years in many cities with several variables.The results were always the same - 100% agreement between cancer patients and geopathic stress zones.

In 1995, a seven-year study with over 8200 patients conducted by the Institute for natural medicine and geopathology in Kassel, Germany evaluated the effects of geopathic stress on the health of people. Every medical treatment is it traditional or alternative seemed to be drastically prolonged or even blocked due to geopathic stress zones. As soon as these structures have been avoided or shielded, medical treatment promptly taken and showed positive results.

Damage of modern technology

Just consider that scholars such as Dieter Ashoff and oncologist Dr. Ernest Hartmann pointed out that about 96% of cancer cases detected by them were related to the presence of geopathic radiation detected in the vertical beds of the sick.

With the conduct of various studies, it was observed that the people who still live in close contact with nature and then corrected according to physiological rules; do not record the typical conditions that characterize today's society. The progress of architecture, in fact, although motivated by the improvement of the living conditions of human beings, resulted in damage to the balance of nature by altering the geological context. The mutation caused the environment as well, is starting to become a real danger to human existence: the alteration due to contamination of the environment and the buildings in which the human being lives is, over the years, increased to arrive at a state particularly critical. The cause of this alarming situation lies in the swift reconstruction took place at the end of World War II, without geobiological assess the needs of our homes.

In this regard, spoke bio-architecture that studies such as how to build buildings can affect the health of people, considering that the methods used in the construction of the houses are able to change significantly the influence of geopathic radiation, as confirmed from alternative medicine. On the basis of this knowledge came the green building specifically aimed to build buildings that have a positive influence on the human mental and physical. To this end, the primary importance of difficult measurement RGP (Geo Pathogenic Radiation).

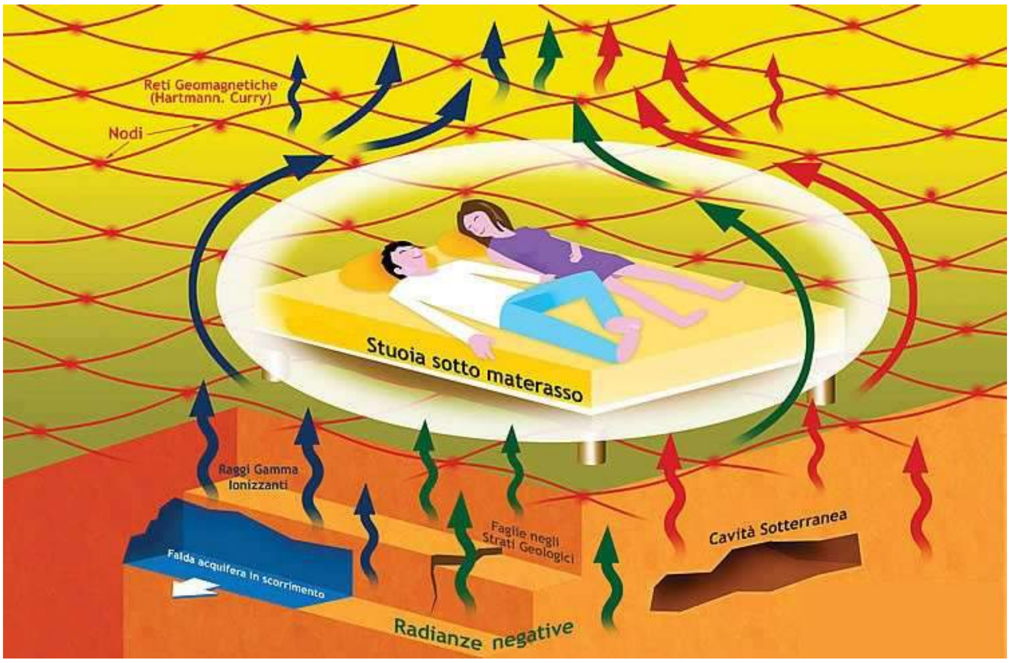


Fig. 1 **Radiation detected in the vertical on beds**

Waterways Underground(or water veins)

It is emit energy that is draining bio-energetic field of our body and can be harmful if a person is spending long periods of time on those areas. It does not matter how deep the water is down in the ground or how many floors a person lives above ground. Even on the 20th floor of an apartment building, the effect can be clearly heard, sometimes even stronger thanks to the exploitation of iron in concrete ceilings.

If your bed seems to be just above an underground stream, your sleep is likely to be affected. It might take a long time to fall asleep or do you toss and turn all night.
The effect of groundwater may have an effect more or less intense depending on whether it is rain water more pure (at least in theory, due to air pollution), or water rich in minerals, as with a greater conductivity.

The water can also drain traces of radioactivity and load anybody, stones, clay, marl, gravel which in turn become broadcasters. In this way into the ground and underground water pockets originates a factor that amplifies the sum and anomalies, and can easily cause serious effects on mental and physical health of the inhabitants.

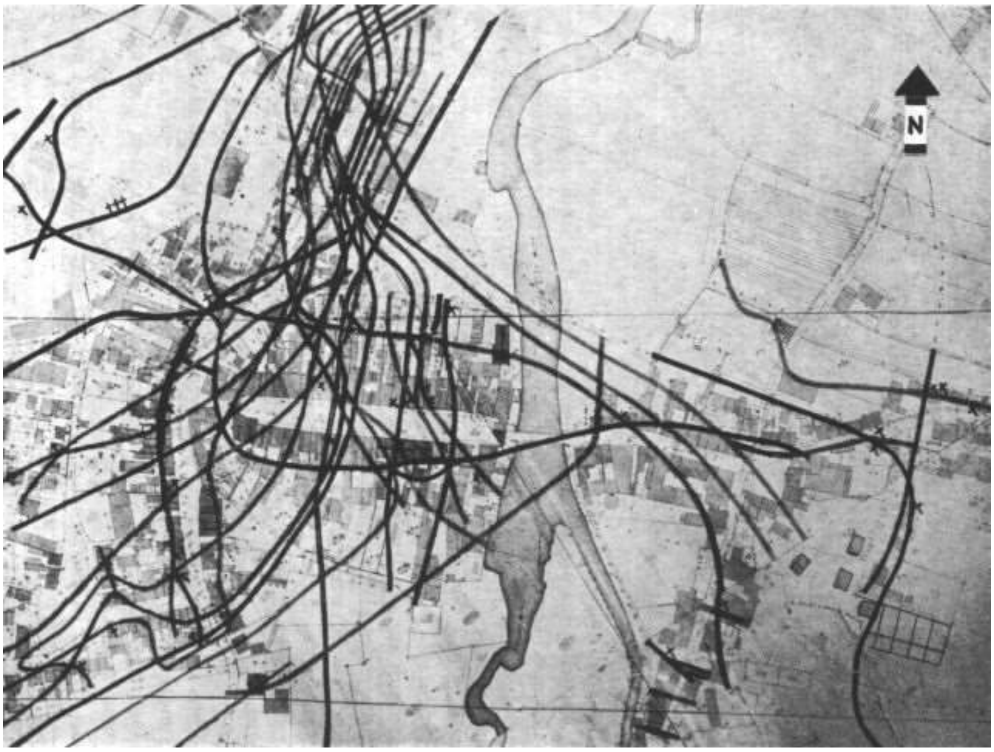


Fig.2 Gustav Freiherr Von Pohl – Vilsbiburg Map of Waterways Underground – 1929

Water veins emit an energy that is draining our body's bioenergetics field and can be harmful if a person is spending long period of time above those areas. It makes no difference how deep the water is down in the earth of how many floors a person lives above the ground. Even on the 20th floor of an apartment building the effect can be clearly felt, sometimes even stronger due to enhancement of iron reinforced concrete in the ceiling.

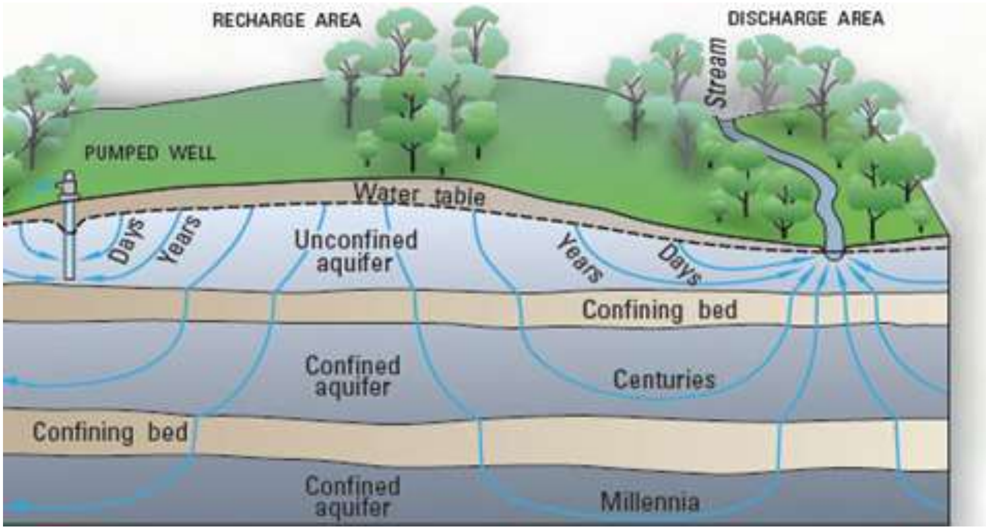


Fig. 3 **In this picture you can see how water flows under the ground**

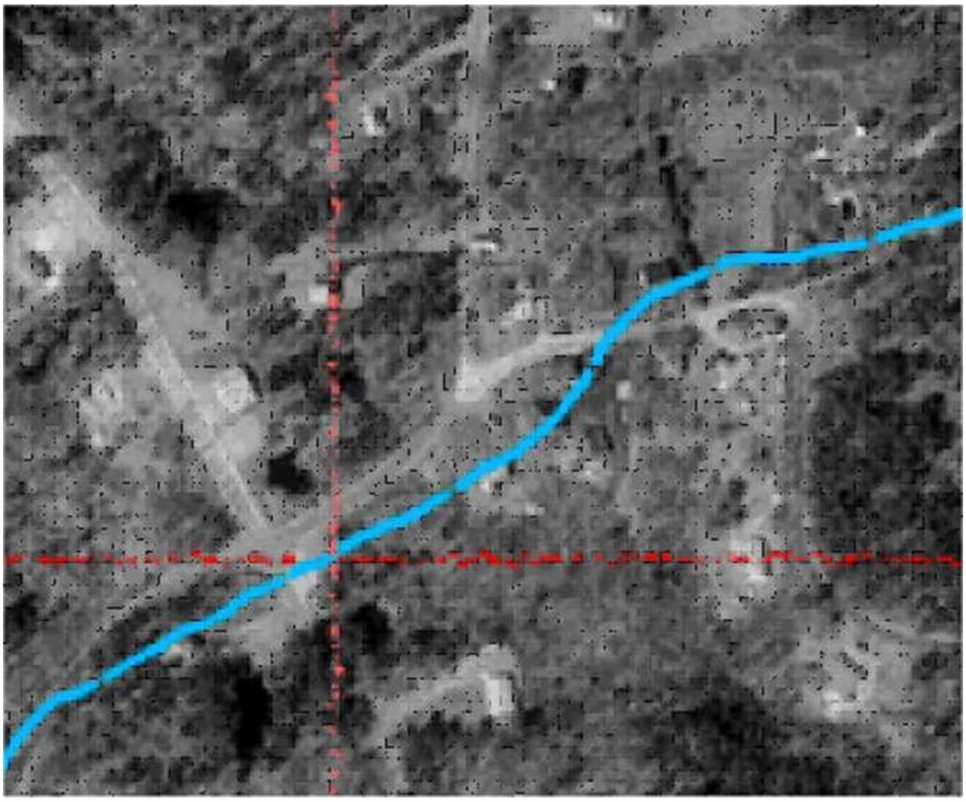


Fig. 4 **Underground water courses from satellite (Norway, Europe)**

If your bed happens to be right over an underground water stream, your sleep will likely be affected. It might take you a long time to fall asleep or you'll toss and turn all night. Waking up between 2 and 3 am is typical, because Geopathic Stress reaches a maximum at this time of the night, especially with full moon. Getting out of the bed in the morning then feels impossible. Babies and small children often fall out of their beds instinctively trying to avoid the Geopathic drain. They wake up several times at night or come to their parent's bed.

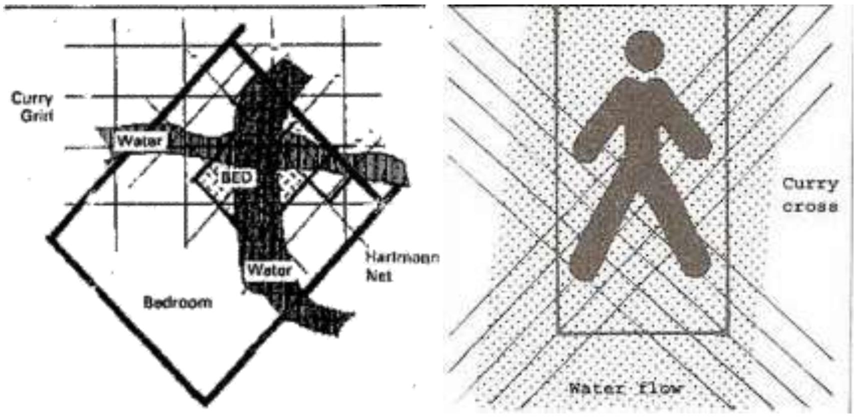


Fig. 5 **In this pictures you can see that bed and the guy is located directly on the crossing of two water veins.**

Grid systems of the Earth

It's made of straight lines or energy ways geopathology. In reality they are more like walls energy, go deep into the earth, but also reach miles above the surface. They are referred to as "cubic" because they are in 3D.

For example, the **Benker-grid** is 10 x 10 m grid. The line itself has a thickness of 8 -12 cm. Dimensions and intensity can vary in function of the geographical latitude and the specific location. Grid systems of the earth have been extensively studied over the last century.

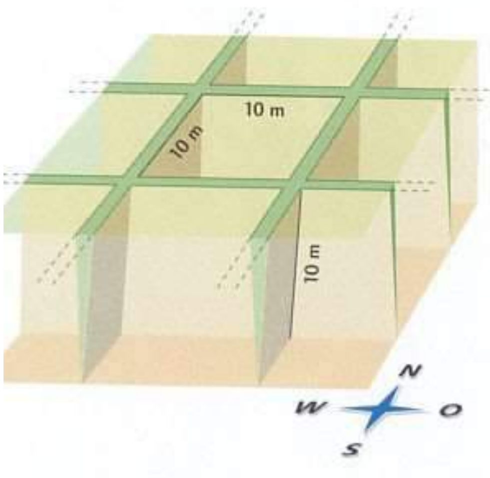


Fig. 6 **Benker-grid is 10 x 10 m**

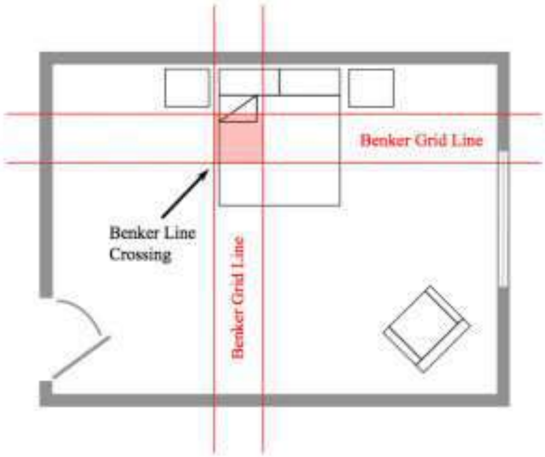


Fig. 7 **Benker Line Crossing**

Three-dimensional grid system

- 2 ½ * 2 Meter Grid or Hartmann-Grid first described by Ernst Hartmann, fits exactly 4 x 5 times into the 10 Meters structure.
- 10 x 10 Meter Grid or Benker-Grid named after Anton Benker, a German dowser from Bavaria.
- 170 x 170 Meter Grid carries a specific energy similar to that of underground watercourses.
- 250 x 250 Meter Grid carries the strongest negative energy, sometimes 45 – 60 cm.
- 400 x 400 Meter Grid with secondary lines 100 feet off the sides of the main structure.
- 3.6 x 3.6 Meter diagonal Grid or Curry-Grid, named after Manfred Curry.

The Benker-grid is a 10x10 m grid, which means the distance between 2 grids lines is about 10 m. The line itself has a thickness of 20 cm – 30 cm. Dimensions and intensities can vary depend on geographic latitude and the specific location. Earth grid system have been studied extensively over the last century. They are often named after their discoverer, The Hartmann-grid after Ernst Hartmann, MD, or the Curry-grid after Manfred Curry, MD.

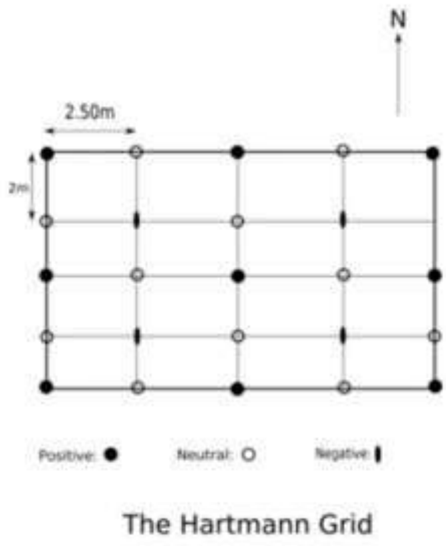


Fig. 8 **The Hartmann Grid**

Ernst Hartmann (10 November 1915 in Mannheim - 23 October 1992 in Waldkatzenbach, a suburb of Waldbrunn (Odenwald)) in Germany was a German medical doctor, author and publicist.

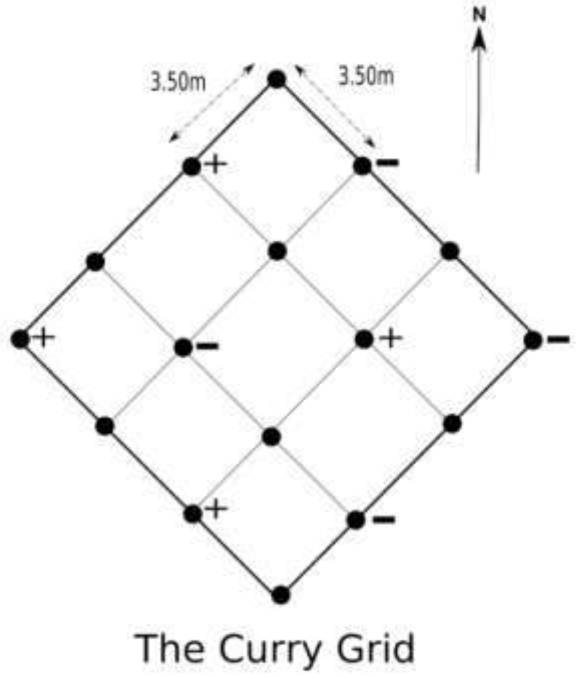


Fig. 9 **The Curry Grid**

Manfred Curry (11 December 1899 – 13 February 1953) was a German born American scientist, physician, inventor, sailor and author. Born in Munich, Germany to American parents.

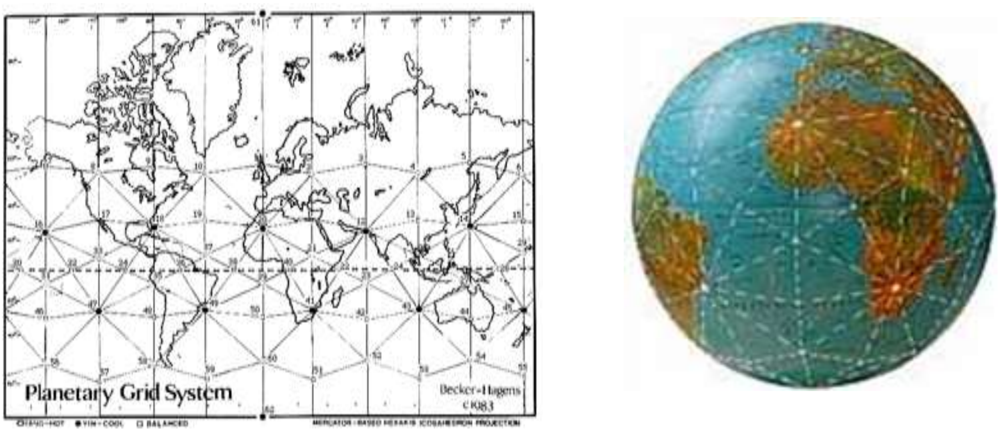


Fig. 10 **Planetary Grid System**

C - Grid + Waterways = Point of overlap

The point of overlap is the most dangerous point for the geopathology stress. We need to know where is exactly for a correct urban planning and architecture planning. It is better if in this point there will be the wall.

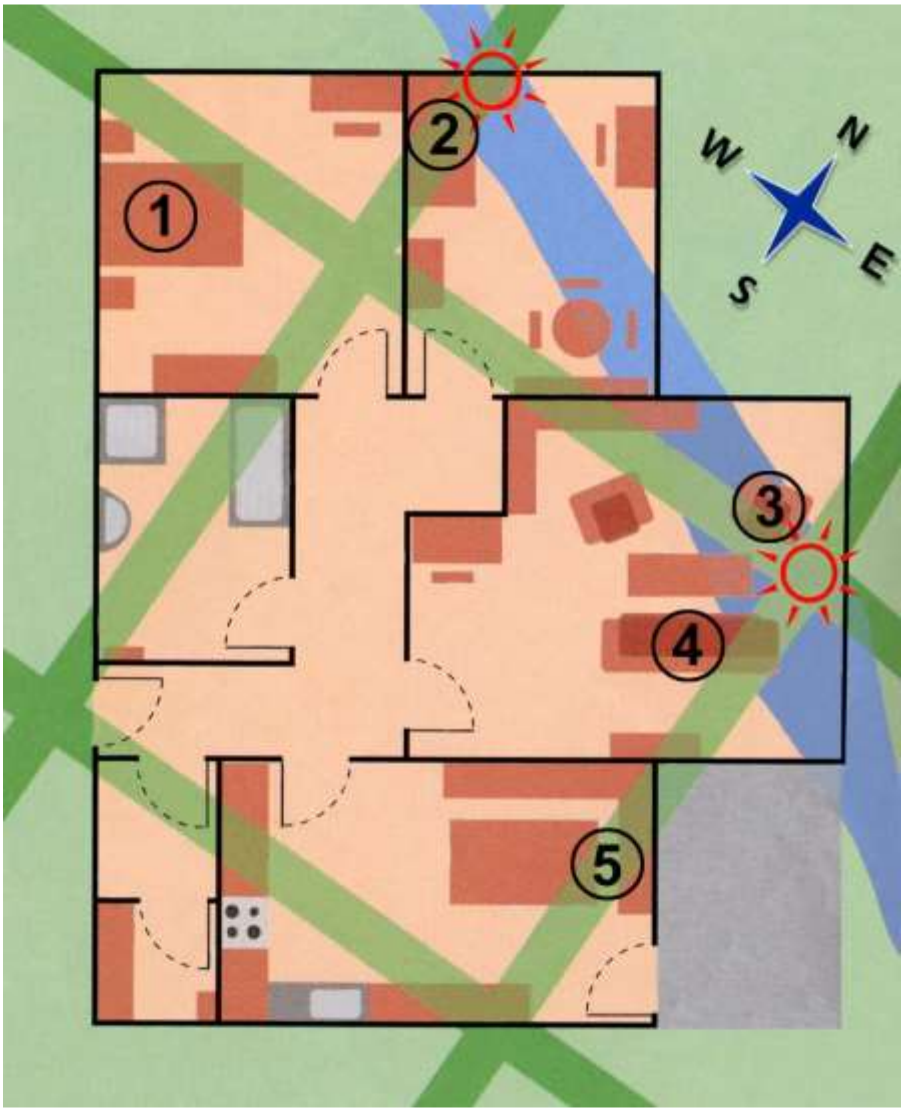


Fig. 11 **The point of overlap of Benker-grid and Waterways Underground**

Geological Fractures

It's naturally occurring fault lines of the earth, but they can also be caused by blasting or quarrying.Here are the most important types of grids of land that were found and documented over the past few decades.Dowsers find these lines using the tools that help them respond to the energies of the earth.

Stress earthquake-The key to understanding the importance of analysis geobiologic of the site where you sleep is so "stress overland". Two people with similar diseases and overall life situation may vary very much like the answer to the care and treatment if one is exposed to stress telluric while the other is not. Last night in the hotel at a high voltage cable and out of a zone of earthquake under stress will leave the only sign of stress in the memory of a troubled sleep and malaise and fatigue of the morning, just recovered from a little 'outdoors or a good rest in your own bed. But if, instead, is just the bed where we sleep forever to be in that condition after a while 'the body is forced to give in and get used to those feelings so strong, and will put more warning signs.

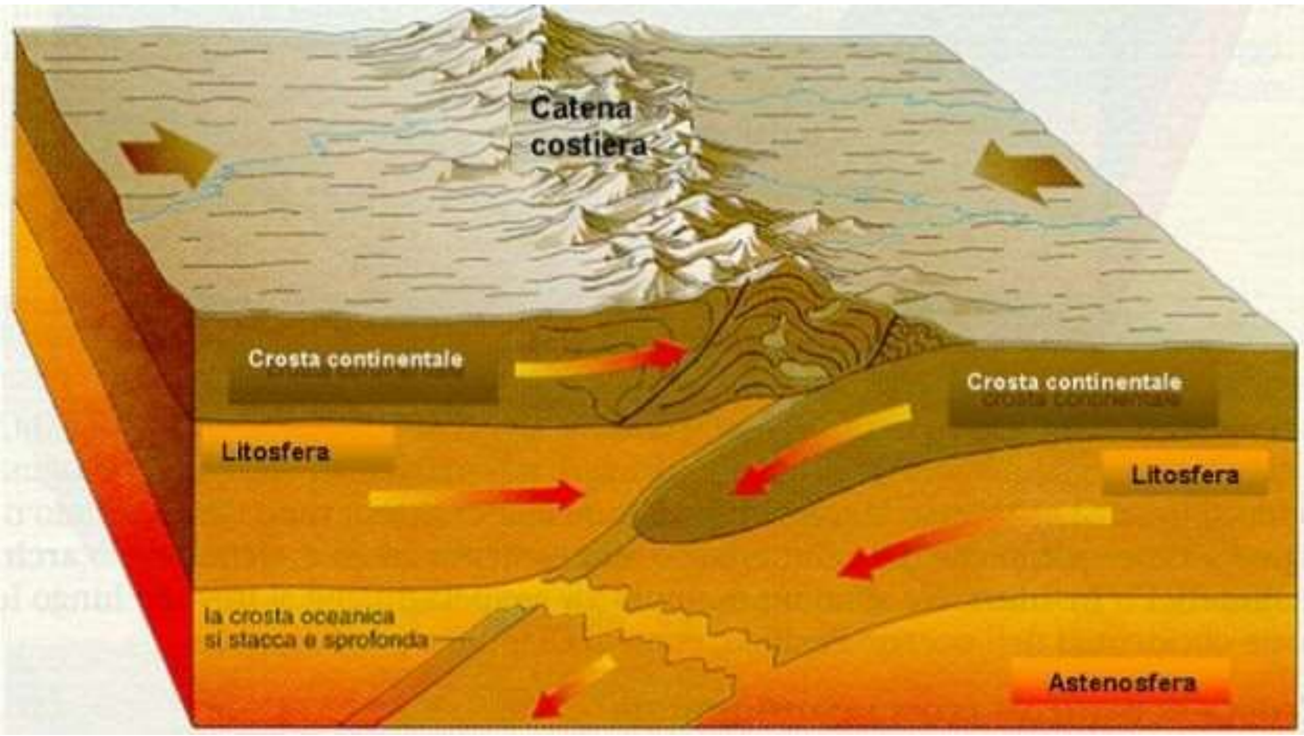


Fig. 12 **Geological Fractures in cross-section of the earth that create geopathology stress**

Geological Fractures are naturally occurring earth fault lines, but also can be caused by blasting or quarrying. Vortexes, an irregular type of geologic energy, are considered in this category, too.

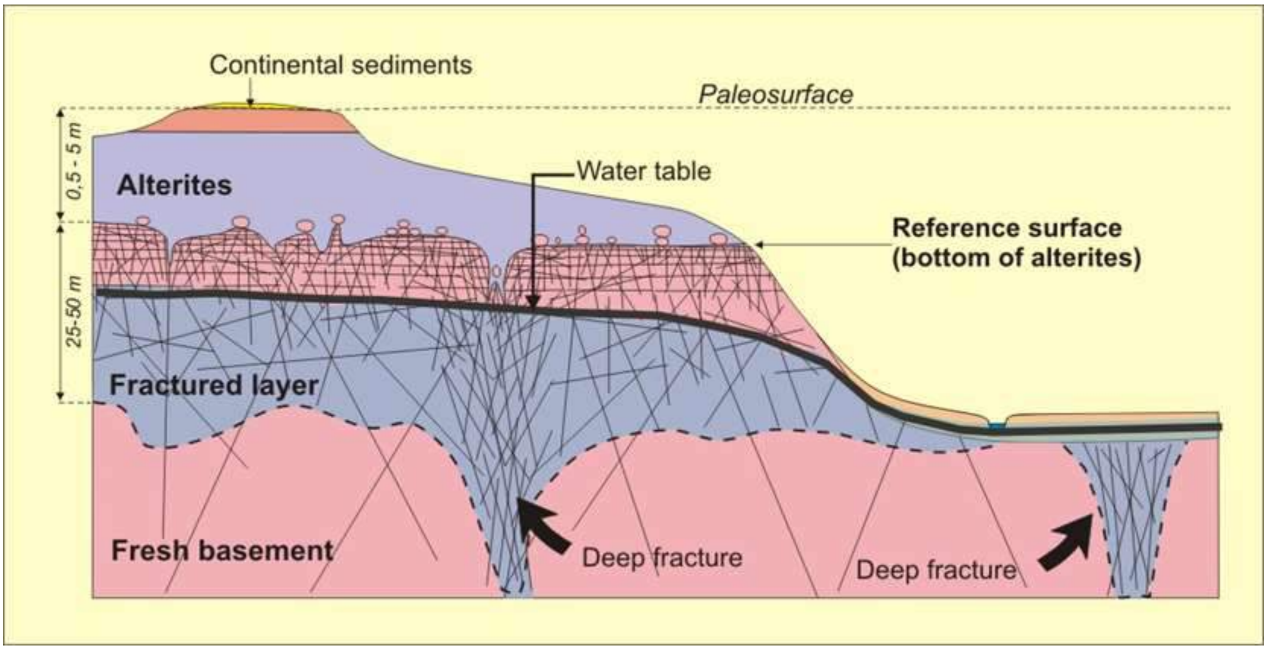


Fig. 13 **Geological fractures**

Impact on Health

Although European research, for more than 80 years, shows convincing evidence that detrimental earth energies affect and diminish a person's health, there is little known about the mechanism in our body of how this happens. Often experienced as general feeling of discomfort of irritating at first, they soon develop into chronic pattern from insomnia to mood swings and many of those indifferent symptoms which doctors don't have time nor resources to find out where they come from.
Discomfort and pain is how the body communicates that something is wrong. Taking away the signals does not resolve the problem. Suppressing the symptoms will just increase the pressure until the problem insidiously pops out somewhere else.

Health Challenges

Here is a list of health challenges associated with people exposed to Geopathic Stress in their environment. Strong electromagnetic fields lead to similar issues and are now receiving increased attention. Studies show that when the sleeping location is changed or shielded properly, symptoms often disappear by themselves or at least improve significantly. In many cases applied medical treatments show better results as the resistance to the healing process has been removed.

Typical symptoms and complains found in correlation with Geopathic Stress:

- ADHD (Attention Deficit Hyperactivity Disorder)
- All cancers!
- Allergies
- Angina
- Arthritis
- Asthma
- Insomnia
- Stomach and digestion problems
- Diarrhea
- Back pain
- Joint pain
- Chronic head ache
- Vegetative dystonia
- Infections
- Bronchitis
- Panic attacks
- Diabetes
- Overweight
- Neurodermitis
- Thyroid problems
- Kidney and bladder diseases
- Tinnitus
- Blood pressure
- Hyperactivity
- Bedwetting
- Alcoholism
- Liver/gall/pancreas problems
- Heart and heart rhythm problems
- Depression
- Hair loss
- Increased yeast infections
- Colitis
- Chronic fatigue syndrome
- Multiple sclerosis
- Digestive problems

(List was compiled by Bachler 1976, Kopschina 1992, Dauna&Dauna 1995 (incomplete))

Here is the list of additional issues specifically related to EMF exposure:

- Sleep disorders, weakness, fatigue
- Headache, dizziness
- Feeling of discomfort
- Difficulty in concentration
- Depression,
- Memory loss
- Visual disruptions
- Irritability
- Hearing disruption
- Skin problems
- Cardiovascular
- Loss of appetite
- Nausea
- Attention deficit
- Electro-hypersensitivities
- Neurological diseases, such as MS
- Parkinson (not yet conclusive)
- Autism (not yet conclusive)
- Immune system disorders
- Leukemia in children and grownups
- Skin melanoma,
- Bladder and other cancers

Electromagnetic Fields

The study also includes geopathology of artificial electromagnetic pollution. Because of the relevance of the use of wireless technology, in particular, we believe that electromagnetic fields (EMF) will be one of the biggest challenges of environmental health for generations to come.

Until the twentieth century, the largest emitter of electromagnetic radiation was the sun. Today, the fields' overlap of radiation permeates our entire modern world. As a result of current technology, including mobile phones, computers, wireless devices, we spend our lives every day in a multitude of fields of electromagnetic radiation at low and high frequency. Some of the worst culprits are the kitchen and personal care products such as hair dryers and blenders. Few people are aware that their healthy smoothie involves an overdose of electromagnetic fields (Produced by the powerful electric motor), spoiling the of having fresh fruit and vegetables.

Every object that generates an electric charge creates electromagnetic fields, some much more than others.

Interest in electromagnetic fields has taken on increasing importance in recent years due to the contemporary fast-paced development of new telecommunications systems, whose plants have spread so widespread in urban areas, raising doubts and concerns about their dangers. Even the intensification of the electricity transmission network, following the increase in demand for electricity, as well as the urbanization of previously uninhabited areas and are characterized by the presence of power lines or radio and television, have helped to give rise to concerns about the possible health effects resulting from the prolonged stay in the vicinity of such installations.

The phenomenon commonly called "electromagnetic pollution" is linked to the generation of electric fields, magnetic and electromagnetic artificial that is not attributable to natural background terrestrial or natural events.

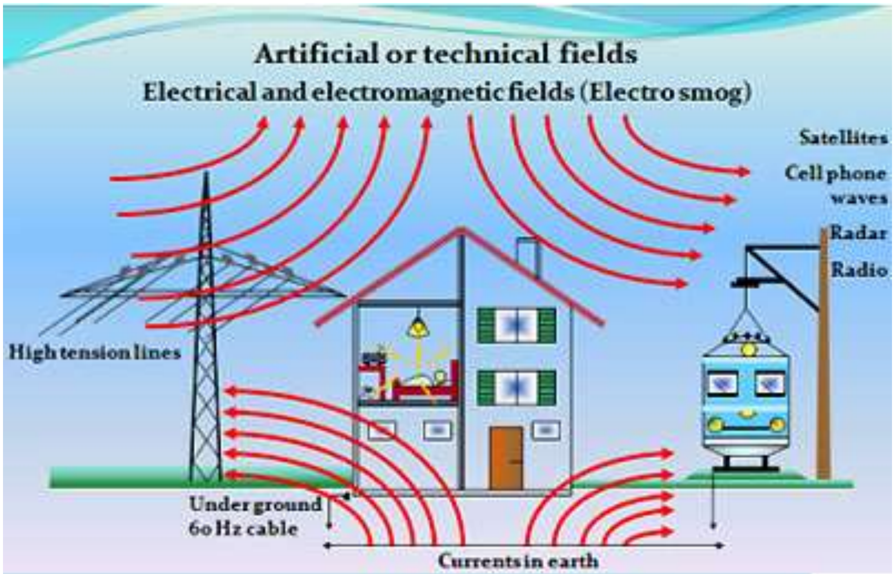


Fig. 14 **Electro Smog**

Radon Gas

What is Radon? - In chemistry, Radon is classified as one of the rare gases such as neon, krypton and xenon. Radon is radioactive, is spread through the air from the ground or water where it can melt. In the open space is diluted by air currents and reaches only low concentrations. In enclosed spaces, however, can accumulate and reach high concentrations, making it very dangerous. Those who live in areas where radon is present, it is in fact subject to its harmful radiation that can even cause lung cancer in those individuals who are already predisposed. Radon gas is generated continuously by soil and in some volcanic stones rocks in particular by lavas, tuffs, the pozzolans, some granite, and so on. It seems that the concentration of radon is higher in volcanic materials; however, happen to find a high level even in sedimentary rocks such as marble, marl, flinch, and so on.

Because it dissolves in the water can reach great distances from the place of training. Because of its origin does not arouse surprise to know that it is sometimes present in building materials.

How to get Radon in our homes? - In nature, radon is present in porous rocks and sands Uranium. It may therefore come from outside, exhaled from the ground through a dirt floor or a concrete cracks. Another step you can find it at the cables and pipes. It can also come from the walls, if they are made of materials loaded with radon or water flowing from the tap if it is present in the dissolved gas. For the construction of buildings are particularly dangerous: tuff, aluminous cement and pozzolan rock, this is much less the Portland cement. When it comes to building materials, there is a big difference in the level of radon present in the various areas of extraction. There is research to catalog the land most at risk, but there is still no comprehensive list.

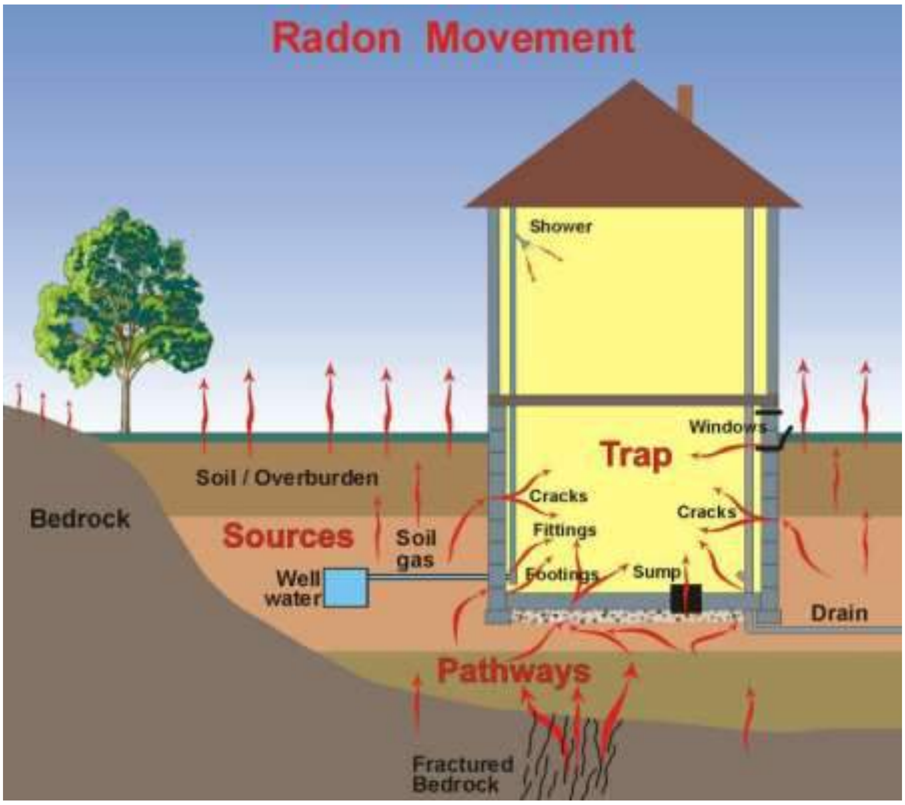


Fig. 15 **Radon Movement in soil**

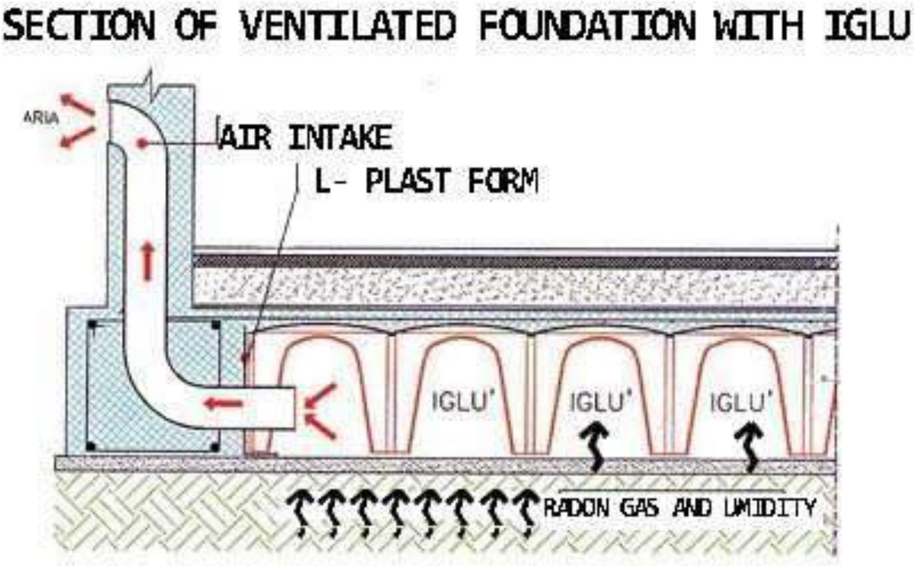


Fig. 16 **Solution to remove Radon Gas in house**

Observe the Nature

Before building a new home inspect the property for the trees crippled or dead, wet earth and anthills. This is often an indication for waterway underground and fault lines of the earth.

Observe your garden. Trees with trunks split or knotted bark, as well as the holes in a row hedge signs of grid lines crossing.

Move designed home in another part of the property, its solution.

Fig. 17 **Particular case in woods of Ryazan – Russia**

FengShui - A Mathod of Enviromental Design

Feng-Shui (wind and water)is a metaphysical naturalist science; the discipline is aimed at finding the "best orientation," as the right location in space so that a person can enjoy more favorable influences to her, at any given time and in a given context.

If this process of maintaining energy balance could be facilitated by contact with sources of vibration related and therefore "nutrients" such as those found in nature, modern life in artificial environments by vibrational frequency absolutely incompatible makes adaptation more difficult and tiring for the man.

"Quality vibrational "energy of the environment, and its" balanced flow "are the two elements that should be considered to help maintain an optimal level, and frequency of the energy in our bodies, in relation to the space in which we live.

The evaluation of the plan of the house with respect to this map, suggests appropriate actions to balance or enhance an otherwise missing or insufficient. From the combined analysis of these factors we can then derive valuable guidance for bring balance and harmony in the energy of our environment, so as to promote a healthier lifestyle and satisfactory in all respects.

The Fengshui in Architecture

For Taoism, the origin of Feng-Shui, the choice of a building site is a very important and delicate phase: we must consider the winds that determine the climate, the topography of the area and the presence or absence of water courses. Not less important is the theory of the five elements, in contrast to the Aristotelian theory that enumerates only four. The five elements and the relationship between man and nature

In the Chinese view the vital breath (ch'i) is at the origin of the principle of Yin and Yang, which in turn causes climate change and then the four seasons, whose interactions originate the five elements. Difficult to explain the infinite reciprocity between Yin and Yang, the four seasons and the five elements, but it is fundamental to understand that proper interaction between these elements is the bearer of harmony, well-being and health for both humans and the environment.

For the Chinese, there is no perfect configuration in the relationship between man and nature, but simply an acceptance of natural changes cooperating with them in their mutual interest. This could perhaps explain our need, in time, to make changes in the arrangement of furniture in our homes.

The energy for the fact Feng-Shui is constantly moving and the task of a good interior designer is to go in the right direction. And with this awareness might explain why we feel the need to have a home entrance large well bright, if it had little energy would remain imprisoned without being able to oxygenate the other rooms. We could understand the reason that leads us to prefer an apartment with many windows, with a few doors, with large spaces devoid of unnecessary frills and furnishings. In Feng-Shui, there are no strict rules since its study places at the center of his research the habits of the people who inhabit the apartment. The general rules that can be formulated specifically to interior design, so they are absolutely valid as daughters of common sense.

Use Bio-Architecture in Feng-Shui

Start with the survey geobiological of identify the most active geopathic radiation (produced by the earth) can create problems for the people.

It adopts the criteria of BIO-ARCHITECTURE:

A - Design systems so that they are "organic" and eco-compatible (compatible with humans and the environment)

B - Use the healthy natural insulation materials, able to ensure excellent levels of breathability for the environments.

C - Check the materials of floor and wall coverings, paintings, furnishings, in order to meet the above criteria and are not sources of noxious fumes.

FengShui Applications in Residential Buildings

Fengshui originated from the observations and understanding of the natural environment that developed when ancient Chinese searched for desirable places to live. Over the years, rules and methods for selecting a housing site emerged; these techniques considered the major elements – rivers, mountains, sun, soil, underground water, and the surrounding environment of the site. The ancient Chinese believed that these major elements could influence the formation and circulation of chi. The ultimate goal of fengshui is to find a place where chi is abundant, so that the site can maximize its benefits for those who live there. Because fengshui is applied on a case-by-case basis, every factor should be considered in the context with others.

There are two major applications of fengshui: site selection of buildings and sites for human settlement. Whether the person searching for a site is an emperor or an ordinary person, the surrounding environment and its effects on housing are very important. This explains why yang house fengshui became a major component in practice and literature. This school originally developed as a means of selecting housing sites in mountain areas, where the natural environmental impacts were primary factors. Detailed methods of yang house fengshui were developed for various locations. Most of these methods are still used with little adjustment since the original transcripts were written hundreds of years ago. In this research, the most commonly used texts are selected to support the interpretation. The literature also shows that the ancient Chinese summarized the basic fengshui principles into illustrated patterns. In the pictures below shows two patterns with the same content: a housing site that is between two parallel roads is not desirable. The one on the left was first published in the Ming dynasty (1368-1644) (Wang, 1985), and the one on the right is a later interpretation (Wang, 2000).

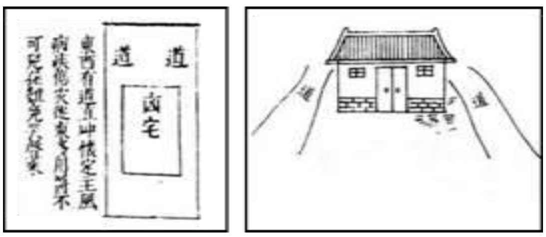


Fig. 18 **Two feng shui patterns**

In general, the rules from the form school were widely applied to housing in mountain areas; on the other hand, when the surrounding factors were related to roads, buildings, and other structures, the principles of the compass school were used. The principles of *yang* house fengshui can also be differentiated into exterior layout and interior design. Four groups of principles further separate the traditional methods when aplied to houses that are located in cities or suburban areas.

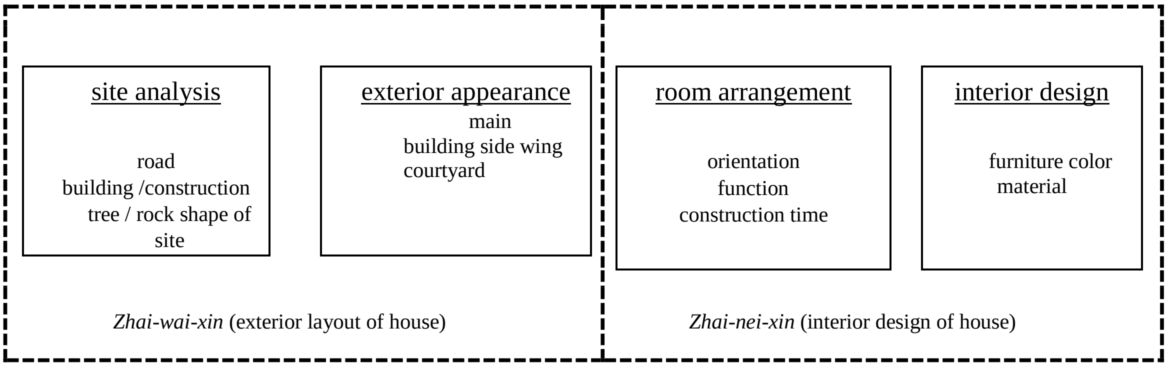


Fig. 19 Four groups of feng shui

Contemporary Environmental Design Principles

After the industrial revolution, western approaches to environmental integration became, in many ways, similar to the eastern tradition of fengshui. Since the 1940s, industrial and chemical processes, such as depletion of the ozone layer and global warming, have caused irreversible damage to natural resources. With this awareness, effective environmental control and improvement methods become one of the most urgent tasks for scholars and professionals in every field. Consequently, several environmentally conscious approaches to architecture have developed, as demonstrated by various projects and publications. During the 1940s and 1950s, Buckminster Fuller created the Dymaxion, an object that can perform at "the greatest possible efficiency with the most current technology." The result was the Dymaxion house. In the 1960s, Paolo Soleri invented the term Arcology to integrate architecture and ecology. A prototype arcology for 5000 people named Arcosanti was constructed near Phoenix, Arizona. In its West and East Housing, passive solar strategies are used to make the indoor space comfortable; while the structure of the foreground, named the Foundry, is designed to respond to changes in the sun angle and to control the amount of shade. After the oil crisis of 1973, many pioneers also began to design houses, such as the "integral urban house" of Ken Baer and Sim van der Ryn, which uses solar energy and other alternative energy sources. Meanwhile, books and publications, including Rachel Carson's Silent Spring (1962), E. R. Schumacher's Small is Beautiful (1976), and David Pearson's The Natural House Book (1989), helped to raise awareness of environmental issues.

Conclusion

After careful research into the immense world of geopathology you can understand how there is still much to study and understand. But the first bold step by having to do would be to recognize the subject in the academic, and not considers it only as a mysterious science and not based on scientific texts. Do not forget that he studies prepared on this subject dating back more than 3000 years ago; could almost be compared to mathematics.

The geopathology as we could see is fundamental for a better life and because of a bad preventing many people die every year and many times without being able to trace the real cause.

A preliminary study of the land before building or restoration should be mandatory in all buildings; then I would add that apply the principles of geopathology to prevent bad situations of life is not only a right for everyone, but a must for design.

The study of geopathology started many years ago and still doesn't stop nowadays. Many professionals are trying to solve this problem and a lot of architects trying to avoid plots where they find any slightest hint on it. Huge amount of equipment where used in previous and it developing to a huge amount of technologies that are used nowadays. I'm sure that people won't stop on that and we could make the heaven on Earth.

Solar RadiationI Control

Direct Solar Radiation

The daylight reaching buildings on the surface of earth is not entirely made up from light coming directly from the sun. Some of the beams are diffused by the atmosphere and some of them are reflected from the ground or other surfaces before reaching buildings. Daylight design is trying to solve the problem of equal distribution and efficient use of all sorts of light (mainly the natural sunlight) that building receives by carefully assessing the quantity and quality of light that a particular site receives.

The intensity of illumination from direct sunlight on a clear day varies with the thickness of the air mass it passes through - a function of the angle of the sun with respect to the surface of the earth. (Atti Della Fondazione Giorgio Ronchi Anno LXVII N.2) Light is less intense at sunrise and sunset than at noon, and less intense at higher latitudes than at lower ones. Sun angle also affects the luminance of overcast skies - at any latitude an overcast sky may be more than twice as bright in summer as it would be in winter. The variations in sky luminance caused by the weather, season and time of day are difficult to codify. (Atti Della Fondazione Giorgio Ronchi Anno LXVII N.2)

The other source of daylight is light reflected from surrounding surfaces - ground, water, vegetation, and other buildings. Reflected light is an important source of indoor daylight for apertures facing away from the sun, particularly in southern Europe where cloudless dark blue skies provide less diffuse light than the cloudy skies of northern latitudes do. The color and the texture of surfaces around a building have critical consequences for both the quantity and the quality of reflected light. (N. Baker 1993).

Shading effect

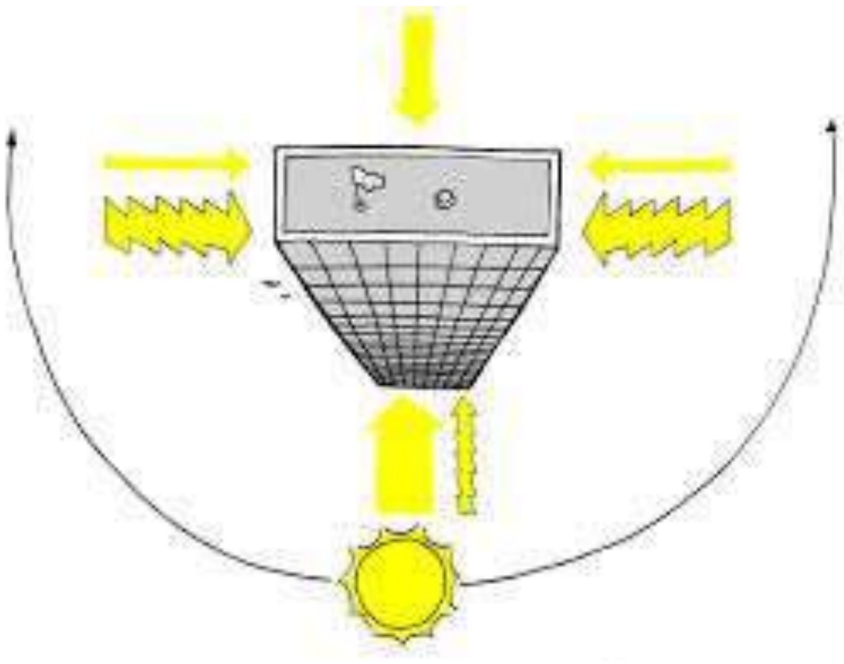


Fig. 20 **Shading effect according to sun position**

The extent of shading effects due to neighboring buildings depend on sun position, building's geographical location and target building geometry and orientation *(Fig.20)* Dynamic calculation of shaded area can be performed following the computational fluid dynamics algorithm with the ESP-r system introduced by Clarke, J. A.

Starting with a collection of target and potential obstruction objects, any vertex consisting of a polygon is defined by a relative co-ordinate system of XYZ, then all the vertices of the obstruction (in this case, adjacent building) are projected parallel to the sun's rays onto the target surface and the projected area is shaded area in that exact moment. It is logical that the greatest shading effect by adjacent building appears in the winter due to the low solar altitude and least shading effect in the summer due to high solar altitude. Therefore, the heating energy consumption increase in the winter usually cannot leverage cooling energy consumption deduction. It should be understood that this is exactly opposite to the shading effect given by designed shading device attached on top of the window whose greatest shading effect is in the summer.

The use of shading device is an important aspect of many high-performance building design strategies. It has been proved that the use of shading devices could improve building energy performance, prevent glare, increase useful daylight availability (between 100 ~ 2000 lux (the SI unit of illuminance and luminous emittance, measuring luminous flux per unit area)) and create a sense of security. Realizing these potential benefits, a varied of shading configurations have been invented and put in the market, such as fixed, manual and automatic movable, internal and external shading devices.

Exterior shading device

Exterior shading device is primary used to control sunlight penetration within the interior of buildings. Such shading devices are always attached on the mullion (vertical or horizontal element that forms a division between units of a window, door, or screen) as a separate component of building envelop, but can also be achieved by disposition of the building floors to create overhangs (protruding structure which may provide protection for lower levels).

Solar radiation enters the interior of buildings through direct beam penetration, sky diffuse and reflection from other surfaces. Exterior shading device decreases direct beam penetration by projecting shadow on the window along the sunlit direction; sky diffuse radiation is also decreased because a portion of sky cannot be "seen" by the window.

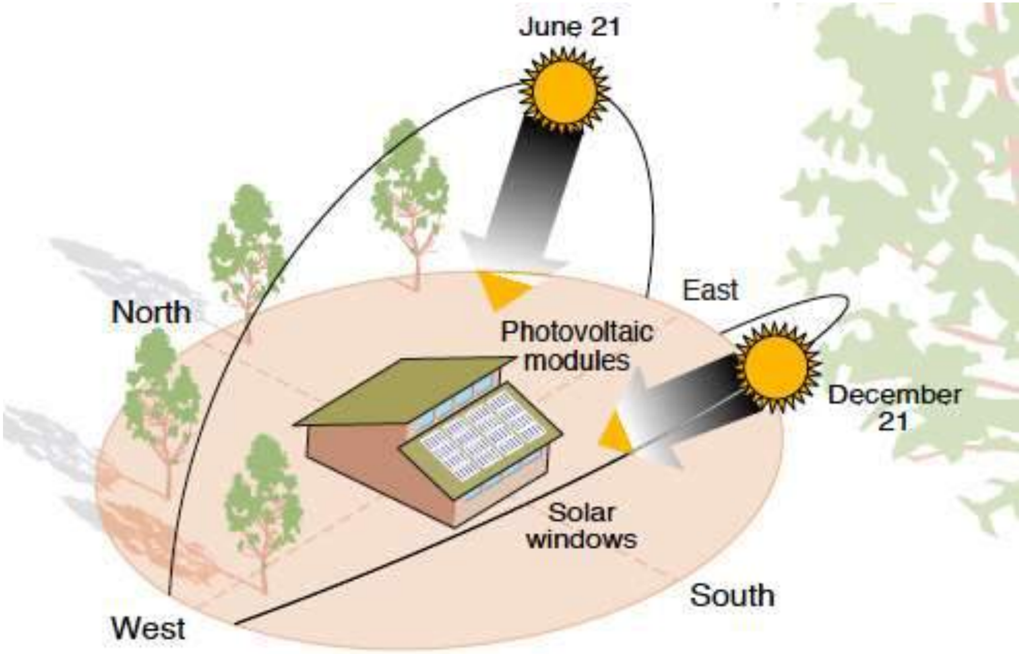


Fig. 21 **Solar position in the sky**

When designing shading devices for heat avoidance, it is important to also balance desired solar penetration during the heating months. Optimal design of exterior shading device needs to trade off the advantage during summer and disadvantage during winter, a simple approach is to consider two extreme solar positions *(Fig. 30)*.

There are two basic types of exterior shading device: horizontal and vertical. Varied combination of these two types create many configurations to accommodate different envelop shapes and orientations.

Besides attaching shading device on exterior of building envelop, may other ways can also prevent sun light from penetrating to the interior of buildings:

- *Interior shading device*
- *Building self-shading*
- *Shaded by trees and other obstructions*

Adjacent buildings

Fig. 22 **Adjacent buildings' shading effect**

As a major component of surroundings of certain buildings under consideration, adjacent buildings will impact building energy, structural and indoor environmental performance through modifying the local solar radiation, natural light accessibility and wind pressure on the building surfaces, buildings need to consider the surrounding to know how shadow from adjacent buildings will affect it *(Fig.22)*. It is intuitive to acquire that adjacent tall buildings will perform as a free "shading device" in the summer and thus may reduce the cooling load by prevent sunlight from reaching to the building.

However, shading effect will also increase the heating load to some extent so that its overall impact needs to be balanced over a year. It is noteworthy that highly reflecting materials may reflect as high as 60% of solar radiation from adjacent buildings onto the surface of the adjacent building, besides direct sunlight, reflected light may lead to unpleasant situations due to risk of glare. Local wind patterns can be influenced significantly by adjacent buildings and this will result in the changes of ex-, infiltration and wind load accordingly as well.

Shading device control

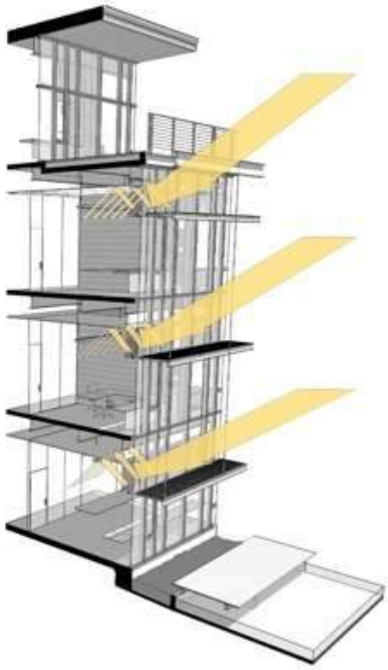


Fig. 23 **Shading device properties**

In order to balance day lighting requirements versus solar gain reduction, the impact of a variety of factors such as glazing area, glazing and shading device properties, task lighting requirement, etc. should be considered simultaneously so that we can observe how shading changes *(Fig. 23)*.

There is no fixed shading devices that could perform optimal at any moment due to dynamic interactions among those requirements and unpredictable weather conditions. Many researches and field measurement indicate that, if an integrated approach for automatic control of motorized shading is used in conjunction with controllable electric lighting systems, substantial reduction of energy demand for cooling and lighting could be achieved (Gugliermetti F 2006).

Solar reflection

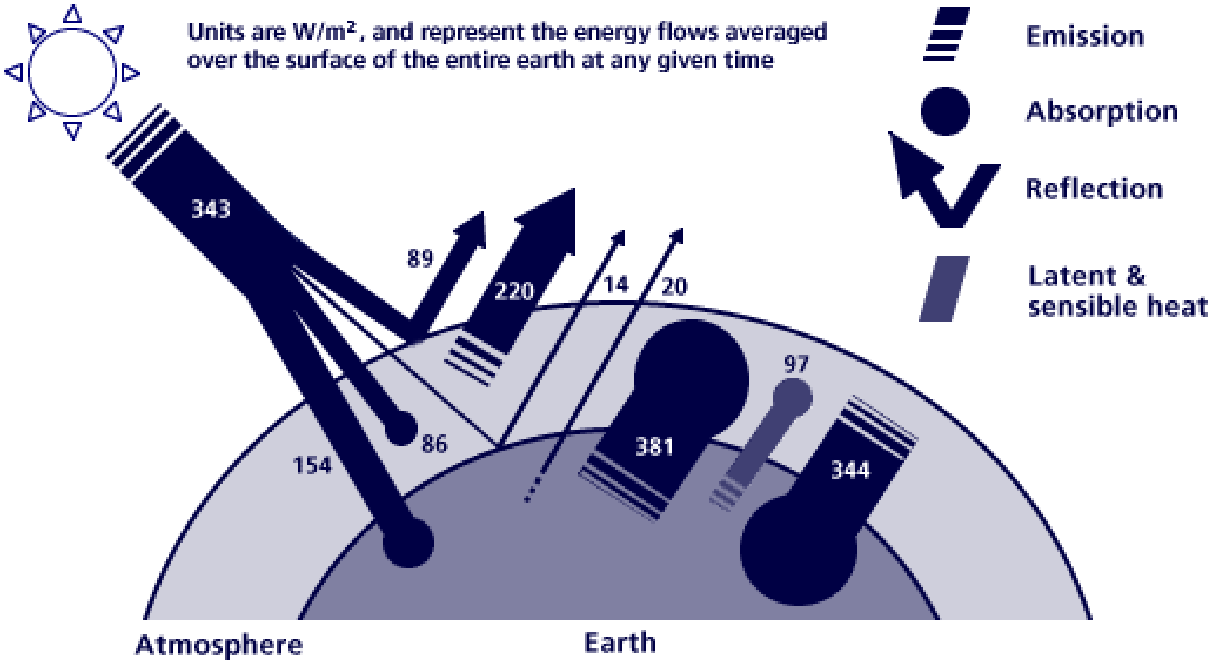


Fig. 24 **Solar reflection**

Depending on the material properties, 10% to 60% of the total incoming solar radiation is reflected through specular and diffuse reflection *(Fig. 24)*. These two distinct reflection mechanisms are involved to determine the amount of solar radiation reflection.

Specular reflection is determined by the law of reflection, which states that the direction of incoming light (incident ray) and the direction of outgoing light (reflected ray) make the same angle, with respect to the normal to the surface. Outgoing light rays from diffused reflection are at many angles rather than at just one angle as specular reflection. View factor (The view factor is the fraction of energy exiting an isothermal, opaque, and diffuse surface 1, that directly impinges on surface 2) is then used to account for diffuse solar radiation projected on a target surface (Tsangrassoulis A 1996).

Sky luminance

Fig. 25 **Standard skies**

Luminance varies across the sky vault - in a heavily overcast sky the luminance will vary by a factor of 3:1 between zenith and horizon, and in a clear blue sky the variation can be as much as 40:1 between the zone immediately around the sun and a point at right angles to the sun in the line of the solar azimuth (defines in which direction the sun is).

The variations in sky luminance caused by the weather, season and time of day are difficult to codify. To meet this difficulty, several 'standard sky' models have been developed *(Fig. 25)*. A standard sky provides approximate or notional luminance values for any part of the sky for use in daylight calculations or design. The simplest model is the Uniform Luminance Sky Distribution. It represents a sky of uniform and constant luminance, corresponding to a sky covered by thick white cloud, with the atmosphere full of dust, and the sun invisible. Another is the CIE (Commission Internationale de l'Eclairage) Standard Overcast Sky Distribution, where the luminance varies from horizon to zenith and corresponds to a day when the sky is covered with cloud and the atmosphere is relatively clear. A third sky is the Clear Blue Sky Distribution, in which sky and atmosphere are clear, and luminance varies in relation to zenith, horizon and the position of the sun. Of these, the CIE Standard Overcast Sky model is the one most commonly used in simulation programs and for the definition of standards and recommendations. Whereas this may be appropriate for northern European countries, it will generate misleading results if applied in southern European conditions with clear blue skies. There are at present no standard models (though some formulae have been proposed) to represent the intermediate, partially cloudy or changing skies, which are so often seen in reality.

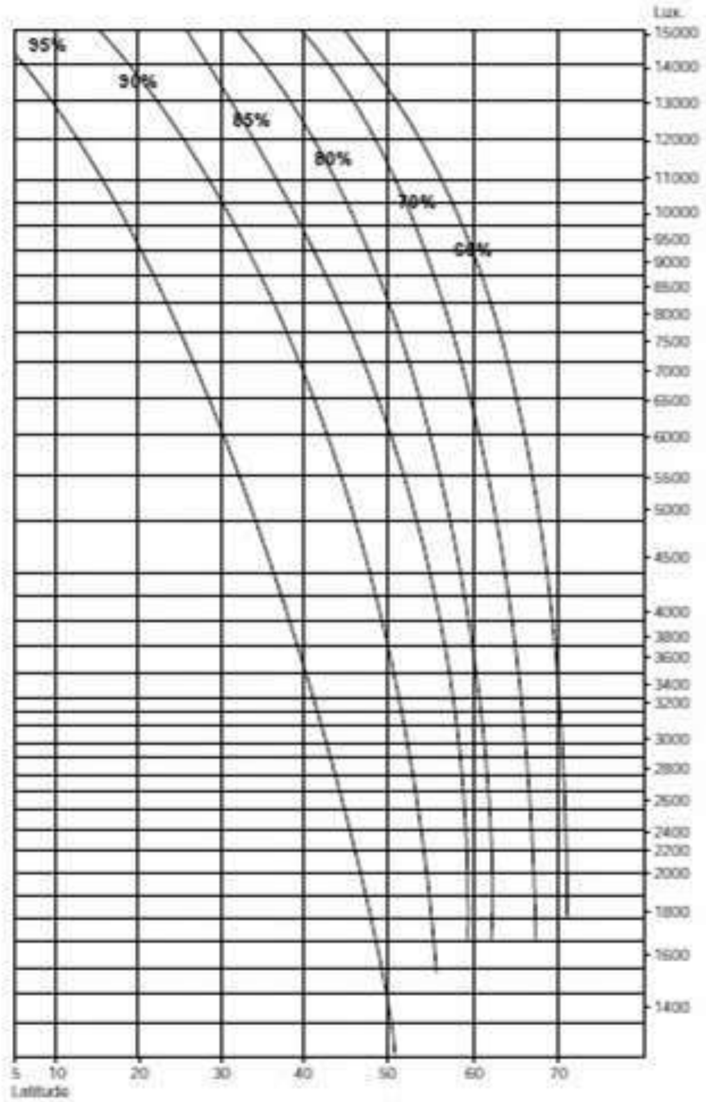


Fig. 26 **Availability of outdoor light as a function of site latitude**

The period of time during which daylight is likely to meet the lighting requirements of a building can be calculated using a set of curves published by the Commission Internationale de l'Eclairage (CIE). These curves indicate for different latitudes the percentage of the working day (7.00hrs to 19.00hrs) during which a required exterior level of illumination on the horizontal plane will be reached *(Fig. 26)*, but they cannot, of course, take account of particular site conditions - overshadowing by hills, trees or buildings, for example, adjacent surfaces, or the design of the building itself.

For most buildings, it is the exterior illuminance on vertical surfaces, which is most critical for daylighting. Meteorological research carried out at 29 sites under the Test Reference Years (TRY) program of the CEC (Civil and Environmental Consultants) has generated estimated figures for global and diffuse illuminances for the horizontal plane and for the four vertical planes facing North, East, South and West. The results are presented in the form of graphs showing daylight availability at each test site during winter, mid- season, summer and for the year as a whole. The test sites were located in Belgium, Denmark, France, Ireland, Italy, The Netherlands and the UK. A separate project has produced similar data for four sites in Germany. Graphs showing illuminances at all 33 sites can be found in Daylighting in Architecture (University College Dublin, Energy Research Group 1994).

Daylight Glare Probability (DGP)

Fig. 27. **Daylight Glare Probability**

Daylight Glare Probability (DGP) *(Fig.27)* is a metric derived from subjective user evaluations in sidelight office spaces; however, DGP can evaluate direct sunlight, specular reflections and areas of bright luminance calculated at each hour as glare sources. DGP also uses vertical illuminance calculated at the eye as a parameter which can influence the glairiness of a space. This means that in exceedingly bright scenes, discomfort can be predicted even without significant visual contrast where DGI (Daylight Glare Index) would predict very low glare due to lack of contrast when using identical luminance data. The calculation of DGP requires a full hemispheric luminance image or a luminance image plus vertical illuminance measured at eye level for calculation.

Detailed modeling of occupant behavior to daylight

Building energy analysis programs such as EnergyPlus, DOE-2 and eQuest use a simplified method of calculating discomfort due to glare which might cause an occupant to lower the blinds. All luminance falling on a window is assumed to be spread across the window surface uniformly from the point of view of the occupant, and direct rays of light do not entire the space.

A slightly modified version of the Cornell DGI is used for determining glare in these programs. DGI was derived from human subject studies in daylight interiors for which the visible sky brightness and size was measured; however, it is not considered to be reliable when direct light or specular reflections are present in a field of view. This is because it relies only upon mean window luminance and not interiorspecular reflections or other direct sources of light. Also, only discomfort due to luminous contrast between the diffuse window and the ambient conditions determined by the split flux method are considered in EnergyPlus.

Ground reflectance

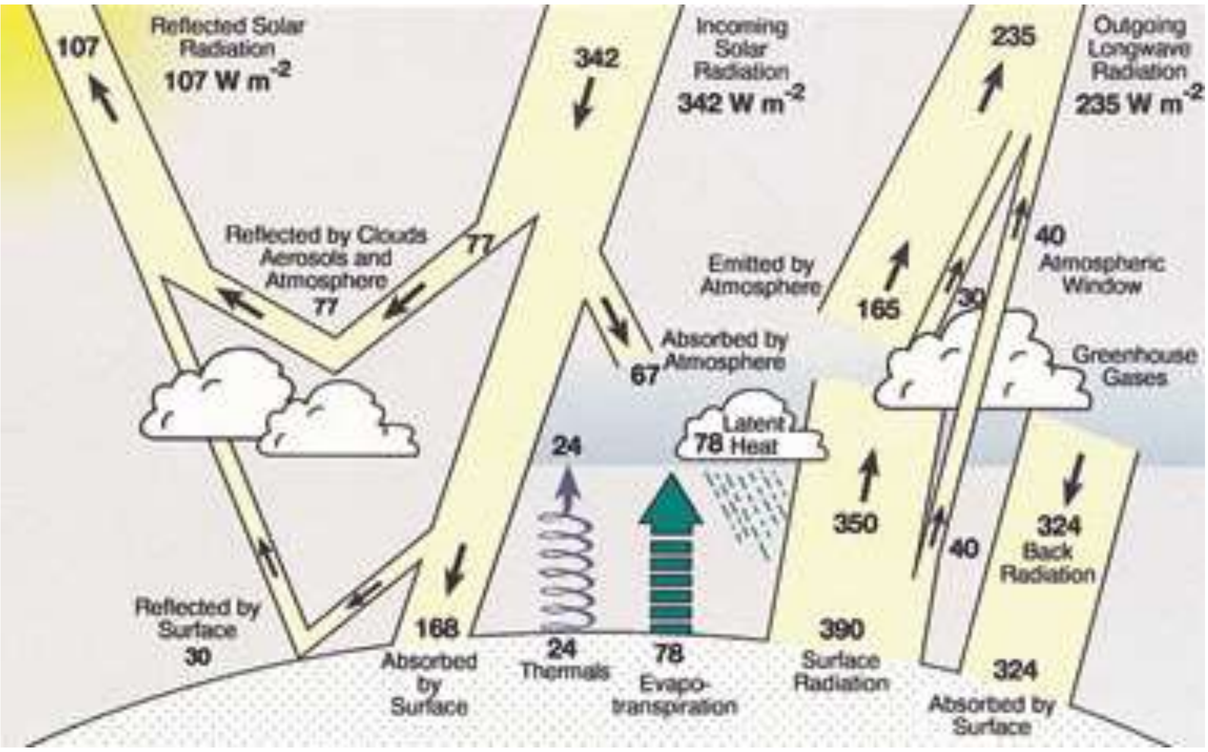


Fig. 28. Ground reflected solar radiation scheme

Ground reflectance (also referred to as albedo) is defined as the fraction of incident radiation reflected by the ground. It varies with a number of factors, such as the properties of ground surface material, solar position, sky clearness, ground vegetation, snow coverage, etc. *(Fig.28)*.

Ground reflectance is mainly used to compute ground reflected solar radiation on the tilt surfaces (like, vertical walls and windows) for building energy simulation, as it will affect cooling and heating load. Solar radiation on tilted surface consists of three major components: solar beam radiation, sky diffuse and ground reflected radiation. In general, ground reflected solar radiation is dominated by diffuse reflectance, thus the fraction of solar reflected radiation onto a building surface depends on the view factor between target surface and the ground, in an open country area. It is noteworthy that in dense urban area, there will be a smaller portion of ground that can be "seen" by the building surfaces; beside, total solar radiation received by the ground is not uniform. In this circumstance, solar reflection from other exterior obstructions cannot be neglected any more so that advanced ray tracing calculation is needed.

Average ground reflectance

As ground consists of a variety of materials, ground reflectance varies both spatially (Space) and temporally (Time). Monthly averaged ground reflectance is always derived to approximate solar reflection from different components of the ground (Psiloglou 2009).

Material reflectance

Surface reflection can be divided into specular reflection and diffuse reflection. For the surfaces like glass or polished metal, specular reflection is predominant such that reflectivity will be close to zero at all other angles except at the reflected angle defined by the law of reflection. Ground is a mixture of many surfaces with distinct properties, diffuse reflection accounts for a major part for most surfaces like grass, concrete, and asphalt.

Snow Covered Ground reflectance

Ground reflectance increases dramatically in the presence of snow, which can vary from 75% to 95% of ground reflectance for fresh snow cover and 40% to 70% for old snow cover (Muneer 2004). Modeling snow effect can be very difficult as snow type, snow depth, ambient temperature, and human activity all influence ground overall reflectance to a certain extent. However, snow reflectance will largely depend on the surrounding of the land. For instance, at the city center the building surface may not "see" much snow as it is surrounded by other buildings, trees and parking lots.

Building control systems

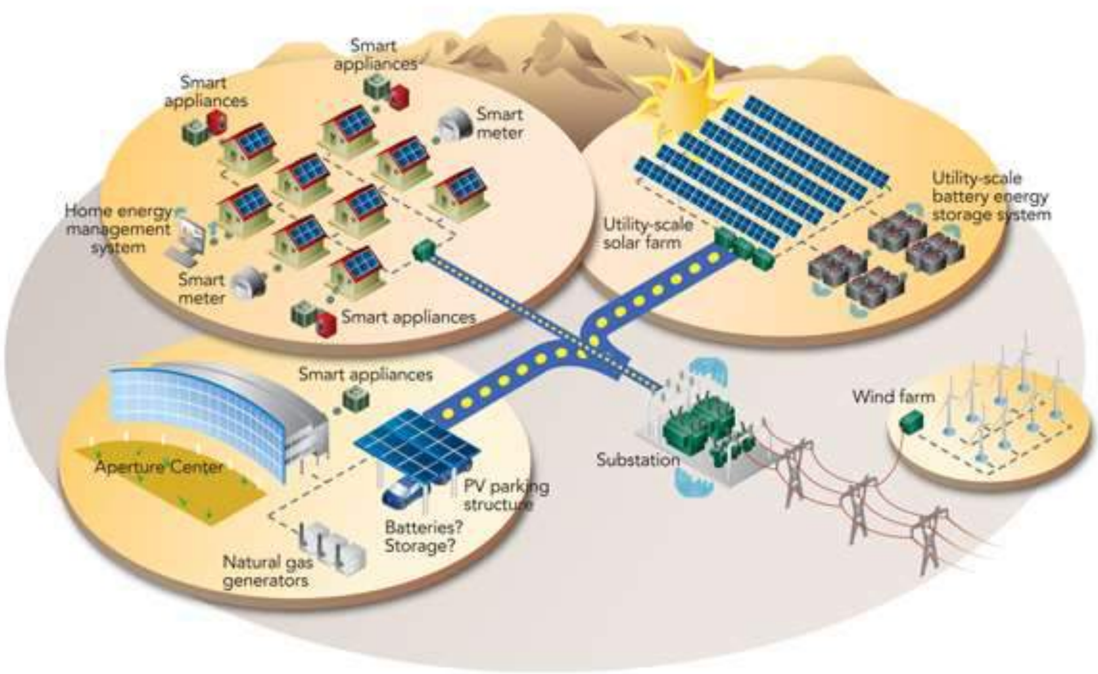


Fig. 29 Building control system

It is most simple to automatically configure the building facade using direct environmental factors, which can be sensed. Most modern energy simulation programs allow the scheduling of whether windows and blinds are opened or closed in response to relevant environmental criteria, such as those listed below*(Fig.38)*:

- Temperature
- CO2 / Air Contaminants
- Occupancy
- Solar Radiation / Illuminance
- Wind speed
- Occupant Behavior

Occupant behavior is difficult to predict; every person has different thermal and visual conditions at which they are comfortable. Thus this is one reason that the ASHRAE 55 thermal comfort standard (Thermal comfort is the condition of mind that expresses satisfaction with the thermal environment and is assessed by subjective evaluation) is a range of temperatures and humilities rather than an absolute goal of perfect human comfort. However, the changes, which a human can enact on a facade, are not so varied. If there is too much sunlight or if a human is experiencing glare, they will likely close the blinds. If someone feels too warm, too cold or too humid while inside a building, with the appropriate exterior conditions, they will open a window. The main difficulty is to decide the threshold at which an occupant will see fit to change the facade state (Goulding 1993).

Active solar space heating

- SDHW—Solar Domestic Hot Water systems

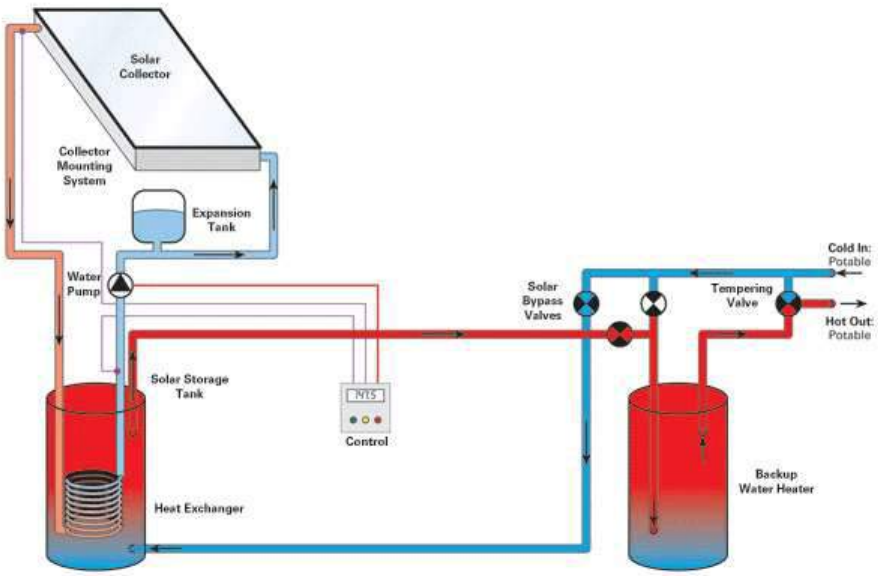


Fig. 30 Solar domestic hot water system

Solar Domestic Hot Water (SDHW) systems supplement traditional hot water heating. The most common system uses glazed, flat-plate collectors in a closed glycol loop. A heat exchanger transfers the energy from the glycol to one or more solar storage tanks. These are usually connected in series to the hot water system *(Fig.30)*. The traditional water heater comes on to keep the water at the required temperature if the solar heat is not enough.

There are seasonal variations in the energy that collect, depending on location, collector efficiency, collector angle and orientation, ranging from about 0.6 to 1.0 kWh/m^2/day in winter up to about 2.4 kWh/m^2/day in summer. It is easy to get 50 percent of hot water energy from the sun. A reasonable target for fossil fuel displacement is 30 to 40 per cent. This allows the panels to operate at a more efficient temperature. These systems are easily integrated into current hot water systems and have a payback in the range of 10 years.

- Photovoltaic (PV) systems

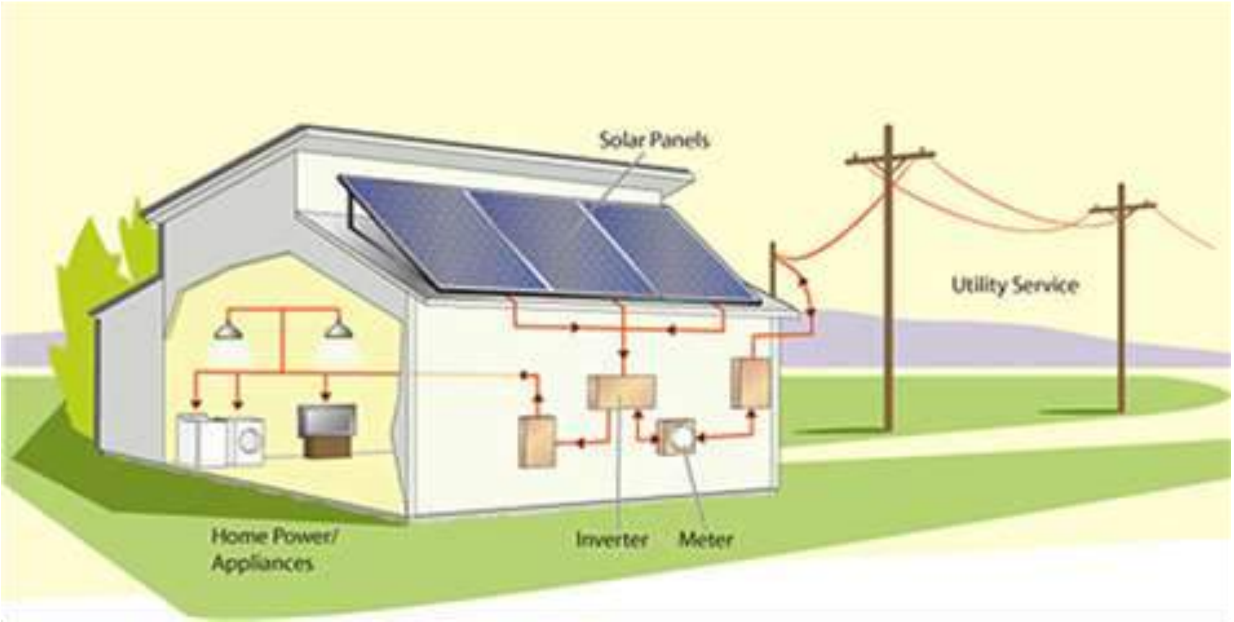


Fig. 31. Photovoltaic system

The photovoltaic effect converts solar energy directly into electricity. When sunlight strikes a photovoltaic cell, electrons in a semiconductor material are freed from their atomic orbits and flow in a single direction. This creates direct current electricity, which can be used immediately, converted to alternating current or stored in a battery. Whenever sunlight arrives at its surface, the cell generates electricity as we see in *(Fig. 30)* solar panels distribute energy to the home *(Fig. 31)*.

PV cells normally have a lifespan of at least 20-25 years; however, they usually last longer if frequent overheating—temperatures in excess of 70^{o}C (158^{o}F) is prevented. PV systems can be used as a building's sole electricity supply or with other sources, such as a generator or a grid connection. The cost of PV technology is now much more expensive than traditional electricity and has a very long payback period (Robertson 2009).

Conclusions

Daylight availability is a design concern that varies throughout the day. The contact with changing natural light is physiologically, psychologically and architecturally important. Le Corbusier said: "Architecture is the masterly, correct and magnificent play of masses brought together in light."

The lighting level in the space is very important. Daylight factor, which is defined as the illuminance received at a point, indoors, from a sky of known or assumed luminance distribution; direct sun- light is excluded from both values of illuminance. Daylight should be maximized subject to the constraints of glare, increased solar gains and possible greater heat loss. Problem of potential thermal discomfort due to direct solar gain at such a position, demand some form of solar control like solar windows.

Even when the main reason of effective use of daylight is to reduce artificial energy consumption, sometimes there is a possibility to make heat gain usability. The art lies in finding the right balance – one key element of which is reducing the heat loss at night by orientating the house to the west or using angled glazing.

In many areas of the world, systems that are design particularly for direct sunlight are not suitable – sunlight is often short in supply. What is more, these systems cannot enhance the diffused light or reduce it. Thus it could seem that these solutions are meant to be for buildings in sunny climates.

Passive Solar Radiation

Passive solar refers to methods of collecting the heat energy of the sun without using any moving parts. In its simplest form, called a *direct gain system*, passive solar is just a matter of orienting the house so that its longest side faces south, putting most of the windows on the south side, putting an overhang over them so the sun does not come in during the summer. In the simplest cases, called sun tempered, the amount of glass is not large, but gets more heat from passive solar, some mass is required. *There are essentially five components to a passive solar building* (Nick Baber & Koen Streemrs 2013)*:*

- ***Orientation:*** *the long south-north axes.*

  Generally, in all climates having the long axis in the east-west direction is the best, whether the idea is to collect solar or avoid it. This is because the south facing sun is high enough in the sky in summer that an overhang will keep it out, and low enough in the winter that the same overhang will have no effect; and in a hot dry climate a reasonable size overhang can be built to keep the sun out all year long. In general, west facing solar gain is to be avoided in all climates because in order to get any in the winter, you get too much in the summer. East facing solar gain is acceptable in cool summer climates, but can also lead to summer overheating.
- ***Windows:*** *orientation and amount of windows face south to collect sunlight*

  Typically, windows or other devices that collect solar energy should face within 30 degrees of true south and should not be shaded during the heating season by other buildings or trees from 9 a.m. to 3 p.m. each day. During the spring, fall, and cooling season, the windows should be shaded to avoid overheating.
- ***Overhangs:*** *the solar collection windows are protected from the summer sun*

  Properly sized roof overhangs can provide shade to vertical south windows during summer months.
- ***Thermal mass:*** *optionally add some mass to hold heat for when the sun is not out.*

  Thermal mass in a passive solar home - commonly concrete, brick, stone, and tile - absorbs heat from sunlight during the heating season and absorbs heat from warm air in the house during the cooling season. Other thermal mass materials such as water and phase change products are more efficient at storing heat, but masonry has the advantage of doing double duty as a structural and/or finish material. In well-insulated homes in moderate climates, the thermal mass inherent in home furnishings and drywall may be sufficient, eliminating the need for additional thermal storage materials.
- ***Insulation:*** *the building is super insulated to keep the heat in.*

  Using greater insulation means that less heat is needed on cold days, and less cooling on hot ones, making the amount of solar gain and night time cooling closer the actual demand.

Windows Orientation and Shading

In sunny southern locations, protecting your windows from the sun is an important component of good window management. The first step is to know how the sun moves through the sky and to orient the building and place the windows in it so as to minimize direct solar admission through your windows. In the northern hemisphere summer the sun rises north of due east and sets north of due west, climbing rather high in the sky at solar noon on the summer solstice. In the winter the sun rises south of due east and sets south of due west, climbing not very high in the sky at solar noon on the winter solstice. (Window Orientation And Shading 2007)

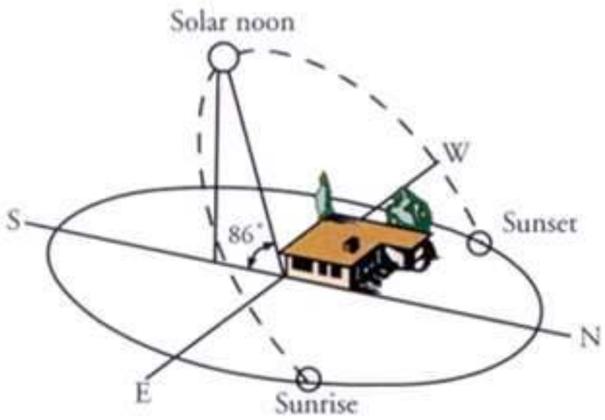


***Fig. 32* Sun path on summer solstice at southern latitude.** (Window Orientation And Shading 2007)

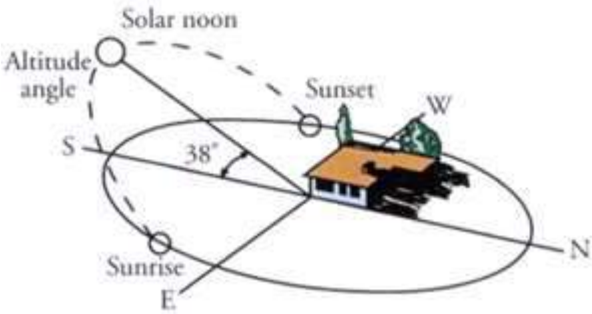


Fig. 33 Sun path on winter solstice at southern latitude. (Window Orientation And Shading 2007)

You can see from these illustrations *(Fig.32; 33)* that it is easy to protect south-facing windows with a roof overhang for all but the lowest winter sun. In climates with cool or cold winters, it might be desirable to allow some solar radiation into south-facing windows, so do not make roof overhang too wide in such cases. In hot climates, however, it might be best to make the overhang wide enough to block the midday winter sun year round.

North-facing windows hardly need any shading, since the only time the sun impinges on them is early in the morning or late in the afternoon in summer, and at those times the angle of incidence is so great that much of the radiation is reflected from the glass or blocked by the walls on either side of the window, especially if the window is recessed somewhat into the wall.

The biggest problems with solar heat gain and the glare which direct sun entry can produce are experienced with east- and west-facing windows. In the middle of the morning and afternoon the sun can be low enough in the sky that only a very wide overhang can be effective (Prowler 2008). In such cases it is best to block the sun outside, before it reaches the glass, using tress, awnings, shutters, or other shading methods.

Another alternative, is to reduce the glazed areas in the building facing the east and west directions and/or to place unoccupied or non-air conditioned spaces on the east and west sides of the building, to serve as buffering or insulating zones.

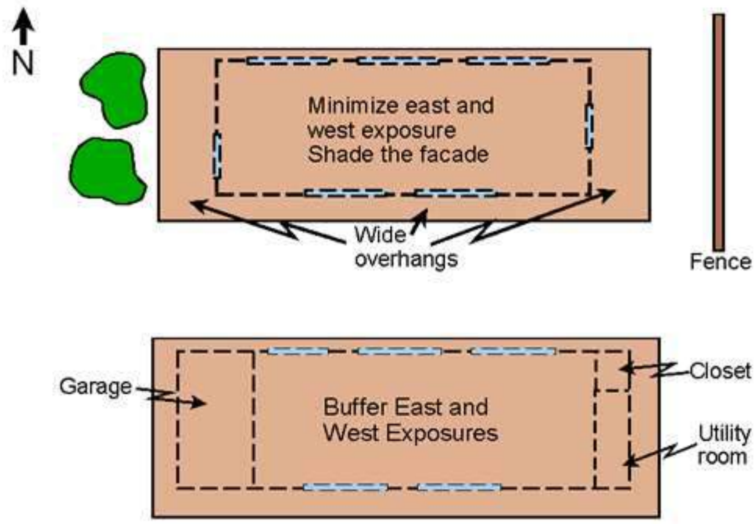


Fig. 34 Best ways of building position. (Window Orientation And Shading 2007)

Examples

Generally, buildings with long axes running east and west have greater solar-heating potential if their window characteristics are chosen accordingly, this means half the units face south and half face north. A partial solution could be a south-facing central atrium or solar heater that pre-heats and delivers air for the north-facing units. Buildings with east-and west-facing orientations have greater potential for overheating in the non-heating season and get little solar gain in winter.

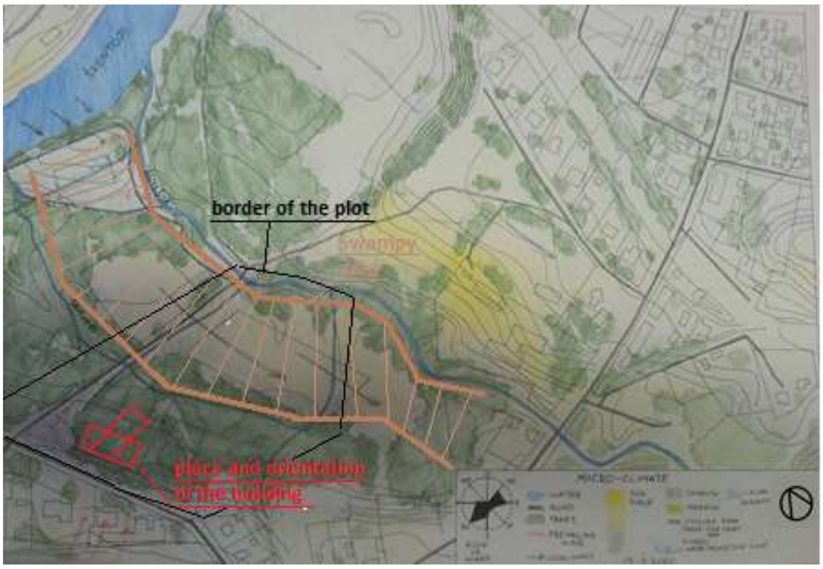


Fig. 35 Analysis and position of the building in Anykščiai(Project of Recreation Complex in Natural Environmentby Diana Markovskaja, 2014 y.)

For example, we can analyse plot in Anykščiai, which was selected as the place for the Project of Recreation Complex in Natural Environment course work. The main problem of this plot (on *Fig. 35* borders of the plot are marked with black line) is that the lowest part which make of the whole plot½ is swampy (brown colour on *(Fig. 35),* and the best way for building position, on my opinion, is on the slope. Furthermore this option of building position gives an opportunity for an attractive view of gardens which are situated in the swampy area.

The building consists of two main parts, two volumes, one of which is with long south-north axes, other with east-west axes. As it was noticed before, the long south-north is not a good axe for buildings, but in this particular situation it will not be a problem, as the facade from the west (south-west) is going to be integrated to the relief, so from this side overheating will not be a problem. Furthermore, this decision protects this part of the building from street noise.

Now, let's take a look at other plot analysis, at the site in the village of Trallong, South Wales. (Pren 2011)

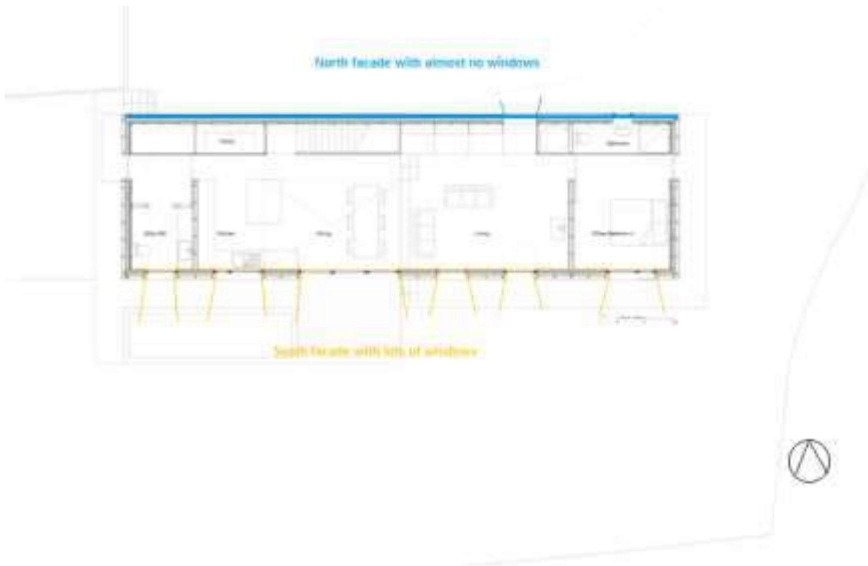


Fig. 36 **Ground floor plan of the Ty Pren house** (Pren 2011)

Analysis of the seasonal sun paths determined the building's location in order to maximise solar gain, views over the valley, and provide a south-facing garden to grow produce. The radical design was backed by a forward-looking planning department, who recognised the potential for the building to set a precedent for future sustainable housing. The compact design is 20m long and 6m deep, forming a sealed box that opens to the south and selectively frames the northern views. Internally, the building is less than 6m deep, enabling natural light and optimal cross and stack ventilation throughout.

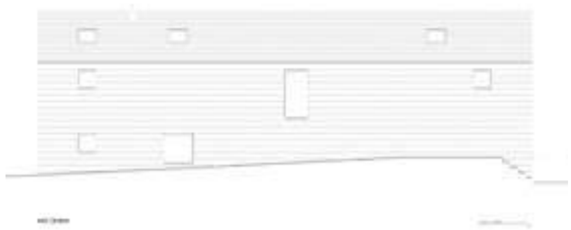


Fig. 37 **South elevation** (Pren 2011)

Fig. 38 **North elevation** (Pren 2011)

The south facing elevation *(Fig. 37)* and fenestration use optimal proportions of glazing; approximately 30% of the south elevation is glazed compared with about 5% of the northern elevation *Fig. 47)*.

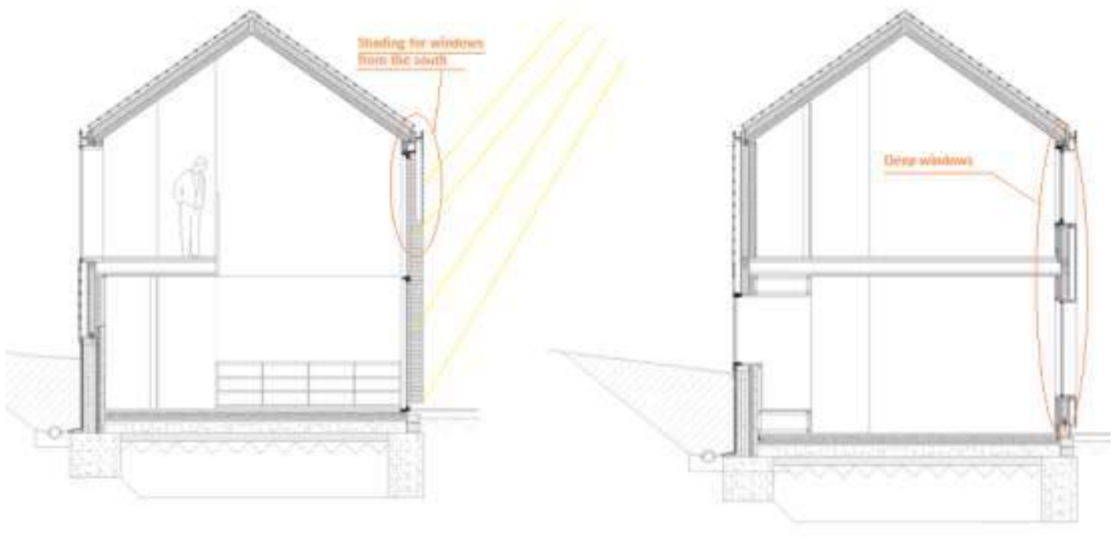


Fig. 39 Sections. (Pren 2011)

Deep window reveals and sliding shutters prevent excessive solar gain in the summer, while the flush north windows emphasise the building's clean form (*Fig. 39*). All these measures are designed to maximise solar gain in the winter and minimise overheating during the summer.

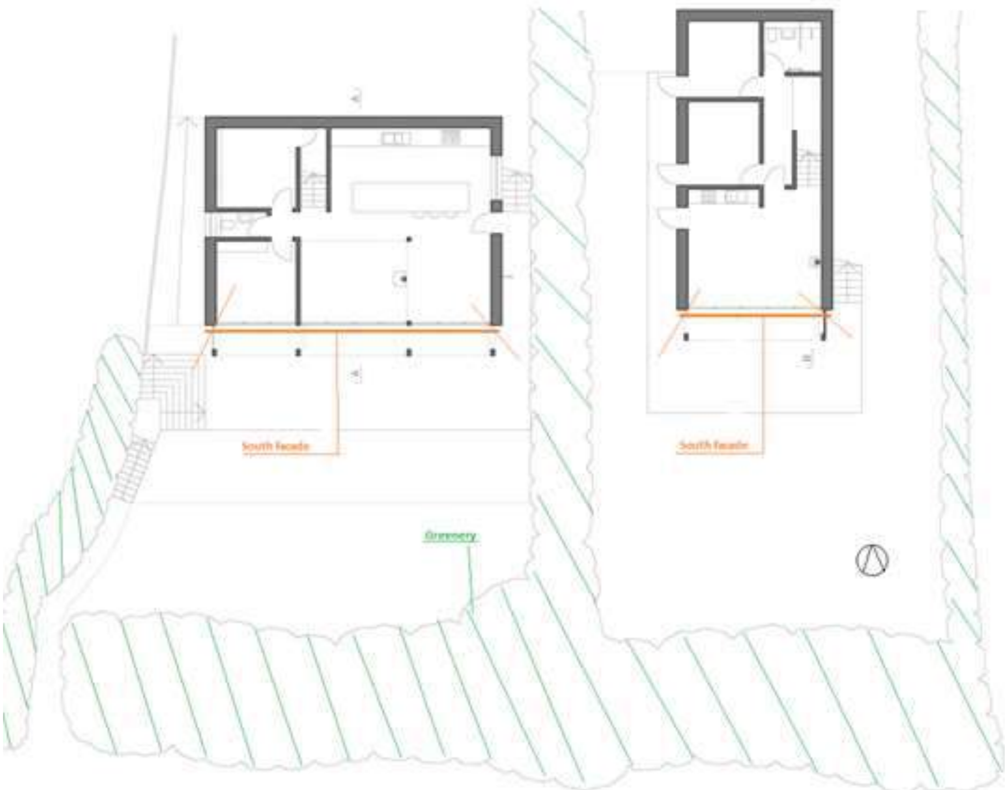


Fig. 40 Ground plan of the houses. (Simon Conder Associates 2013)

In other example from village of Porthtowan, England (Simon Conder Associates 2013), south orientation has been also used to create passive solar gain houses to minimise the use of fossil fuels and energy costs *(Fig.40, 46)*. This has been achieved partly by fully glazing the southern elevations of the houses.

But, to minimise the possibility of overheating in summer the glazed southern elevation is set back behind hardwood verandas, which provide full width balconies at upper ground floor level and protect the interiors from the high summer sun, while allowing the much lower winter sun to penetrate deep into the two houses.

Conclusion and main rules for orientation and shading *(Keith Robertson & Andreas Athienitis 2010):*

- The best position for the building is to be elongated on an east-west axis.
- It is recommended for the building's south face to receive sunlight between the hours of 9:00 A.M. and 3:00 P.M. (sun time) during the heating season.
- Interior spaces requiring the most light and heating and cooling should be along the south face of the building. It is better to locate less used spaces on the north.
- An open floor plan optimizes passive system operation.
- Use shading to prevent summer sun entering the interior.
- Landscape features such as mature trees or hedge rows can also serve as shading.

Impact of the Thermal Mass and Insulation

When there are not that many south facing windows, there is generally not enough solar gain to cause the building to overheat, but as the south glazing goes above, mass is needed to absorb the additional heat *(Fig.41; 42)*. (Passive Solar 2011) The mass serves not only to keep the afternoon temperature comfortable, but to release this extra heat during the night when the sun is not out *(Fig.32)*. In order to be particularly effective in storing solar gain, the sun should shine directly on the mass, and the mass should be a dark colour so it absorbs it all (since the suns energy is all radiant). If the mass is not directly in the sunshine, the air temperature will climb and the mass will absorb heat by conduction from the air, but this process is very slow, especially if the mass is on the floor, because solar gain can easily create highly stratified air.

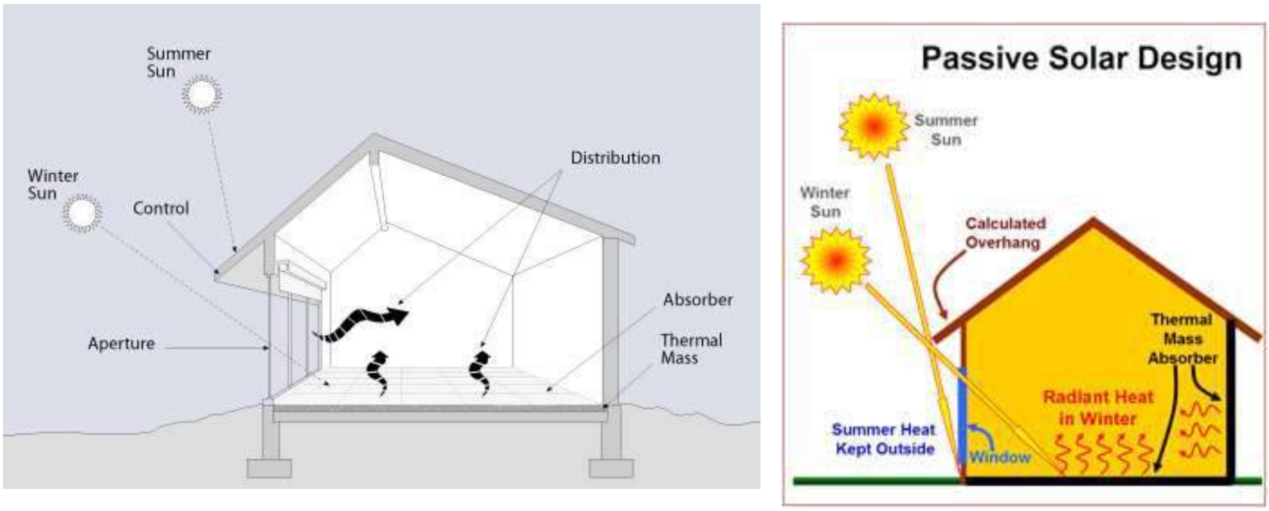


Fig. 41 Thermal mass in the interior (floor) absorbs the sunlight. (Thermal Mass 2009)

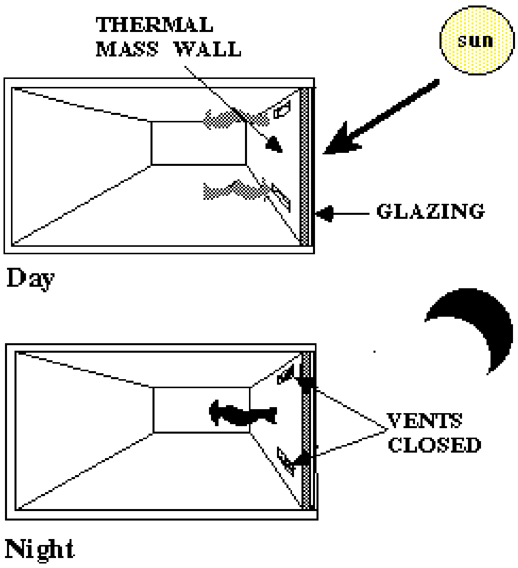


Fig. 42 Thermal mass in the interior absorbs the sunlight and radiates the heat at night. (Passive Solar 2011)

Thermal mass is most useful in locations that have large swings of temperature from day to night *(Fig. 43 – 46)*, such as desert climates. Even if the thermal mass does not prevent heat energy from flowing into or out of occupied spaces, like insulation would, it can slow the heat flow so much that it helps people's comfort rather than causing discomfort (Passive Heating: Thermal Mass 2011).

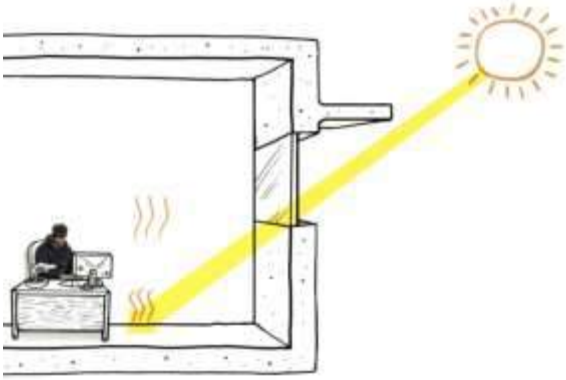


Fig. 43 Insulation prevents thermal gain from leaking into the ground

Fig. 44 Insulate coverings can interfere with thermal mass

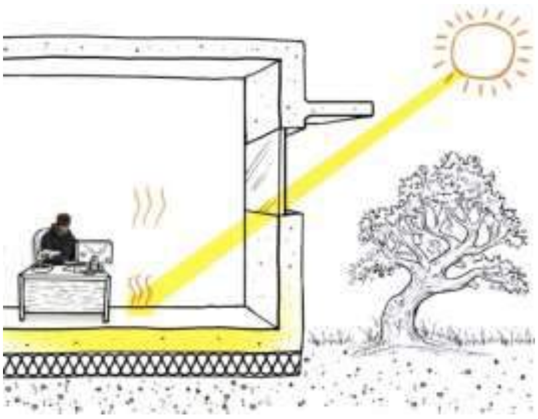


Fig. 45 Insulation prevents thermal gain from leaking into the ground

Fig. 46 Insulate coverings can interfere with thermal mass

In climates that are constantly hot or constantly cold, the thermal mass effect can actually be detrimental. This is because all surfaces of the mass will tend towards the average daily temperature; if this temperature is above or below the comfortable range, it will result in even more occupant discomfort due to unwanted radiant gains or losses. Thus, in warm tropical and equatorial climates, buildings tend to be very open and lightweight. In very cold and sub-polar regions, buildings are usually highly insulated with very little exposed thermal mass, even if it is used for structural reasons (Passive Heating: Thermal Mass 2011).

Masonry walls also provide good thermal mass. Recycled materials can be used (e.g. reused bricks). Avoid finishing masonry walls with plasterboard as this insulates the thermal mass from the interior and significantly reduces its capacity to absorb and re-release heat. Reverse brick veneer is an example of good thermal mass practice for external walls because the mass is on the inside and externally insulated. In traditional brick veneer, the mass of the brick makes no contribution to thermal storage because it is insulated from the inside and not the outside.

Insulation

Insulation can be extremely valuable in preventing direct gain from being conducted to the ground or outside air, where it is lost. The understanding of how insulation works helps to understand heat flow, which involves three basic mechanisms - *conduction, convection, and radiation*. *Conduction* is the way heat moves through materials, such as when a spoon placed in a hot cup of coffee conducts heat through its handle to your hand. *Convection* is the way heat circulates through liquids and gases, and is why lighter, warmer air rises, and cooler, denser air sinks in your home. *Radiant heat* travels in a straight line and heats anything solid in its path that absorbs its energy (Clarke Snell & Tim Callahan 2005).

Most common insulation materials work by slowing conductive heat flow and convective heat flow. Radiant barriers and reflective insulation systems work by reducing radiant heat gain. To be effective, the reflective surface must face an air space.

Regardless of the mechanism, heat flows from warmer to cooler until there is no longer a temperature difference. In a home, this means that in winter, heat flows directly from all heated living spaces to adjacent unheated attics, garages, basements, and even to the outdoors. Heat flow can also move indirectly through interior ceilings, walls, and floors - wherever there is a difference in temperature. During the cooling season, heat flows from the outdoors to the interior of a house.

Examples

In an indirect gain system, thermal mass is located between the sun and the living space. The thermal mass absorbs the sunlight that strikes it and transfers it to the living space by conduction. The indirect gain system will utilize 30 – 45% of the sun's energy striking the glass adjoining the thermal mass. The thermal mass is located immediately behind south facing glass in this system. Operable vents at the top and bottom of a thermal storage wall permit heat to convection from between the wall and the glass into the living space. When the vents are closed at night radiant heat from the wall heats the living space (F*ig.49*).

In rooms with good access to winter sun it is useful to connect the thermal mass to the earth *(Fig.45)*. The most common example is slab-on-ground construction. Less common examples are brick or earthen floors, earth-covered housing or green roofs. A slab-on-ground is preferable to a suspended slab in most climates because it has greater thermal mass due to direct contact with the ground. This is known as earth coupling. Deeper, more stable ground temperatures rise beneath the house because its insulating properties prevent heat loss.

Fig. 47 Earth-covered housing with a green roof

One of examples can be woodland villa in Dutch *(Fig.47; 48)* (Denievwegeneratie 2012).The house is located on a historical agricultural plot amidst hayfields and woods in a nature reserve, in a hilly area. This house is earth-covered. The hill simultaneously functions as camouflage and as a blanket, hiding the house from view from the north side and using the earth as thermal insulation *(Fig.48)*. On the south side, the house has been opened to a maximum. The grand glass facade is framed in timber, which guides the transition from the artificial to the natural.

Due to fact, that south facade is glazed and is maximum opened; the floor is made of the concrete so it functions as a thermal mass which collects sun heat through the day *(Fig. 48)*. Moreover, there are some walls which are facing south (e.g. wall which covers stairs), they are also made from concrete and at some point serves as thermal walls.

Similar situation is in Ty Pren house which we were analysing before (F*ig. 40).* There south facade is opened to maximum too and ground floor is tiled. So there floor serves as thermal mass too.

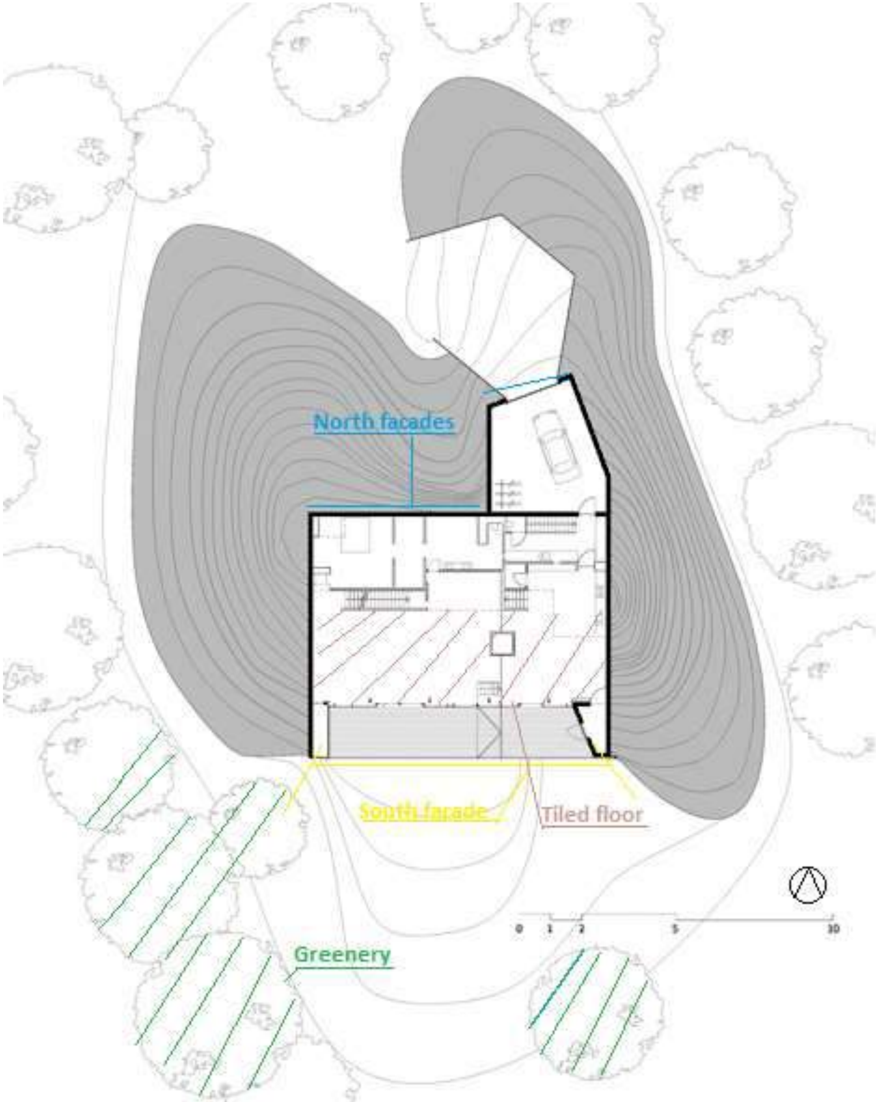


Fig. 48 First floor plan. (Denievwegeneratie 2012)

Conclusion and main rules:

- It is recommended to the exterior of the mass wall (toward the sun) to be a dark colour.
- It is better to use a minimum space of 10 cm between the thermal mass wall and the glass.
- Vents used in a thermal mass wall must be closed at night.
- Thermal wall thickness should be approximately 25-35 cm for brick, 20-45 cm for concrete, 20-30 cm for adobe or other earth material.
- Direct-gain windows should be oriented due south, although the orientation may be varied by as much as 30 degrees east or west of south without losing much efficiency.
- Thermal mass floors that receive solar radiation should not be carpeted.
- In direct gain storage thin mass is more effective than thick mass.
- Locating thermal mass in interior partitions is more effective than exterior partitions. The most effective internal storage wall masses are those located between two direct gain spaces

Isolated Gain, Sunspaces

The most common isolated-gain passive solar home design is a sunspace that can be closed off from the house with doors, windows, and other operable openings. Also known as a sunroom, solar room, or solarium, a sunspace can be included in a new home design or added to an existing home. Sunspaces should not be confused with greenhouses, which are designed to grow plants. Sunspaces serve three main functions - they provide auxiliary heat, a sunny space to grow plants, and a pleasant living area. The design considerations for these three functions are very different, and accommodating all three functions requires compromises.

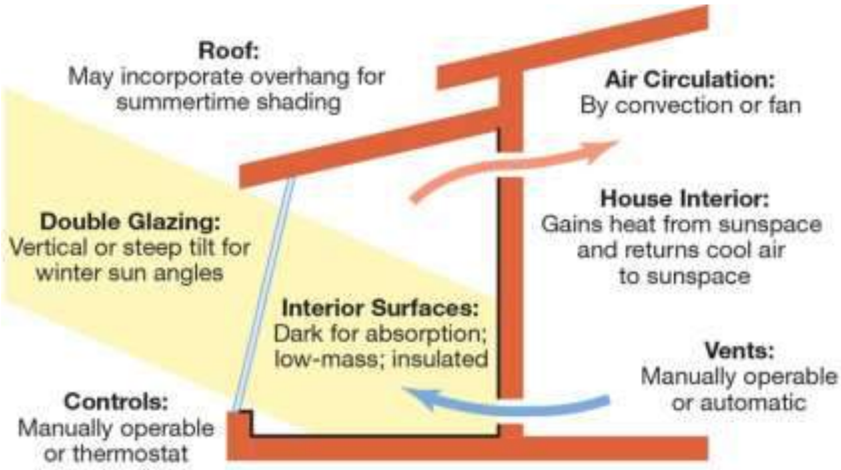


Fig. 49 Sunroom function

Examples

A popular passive solar direct gain heating strategy is the sunspace. The sunspace can be very important in any strategy to retro-fit an existing house with a new sustainable energy source.

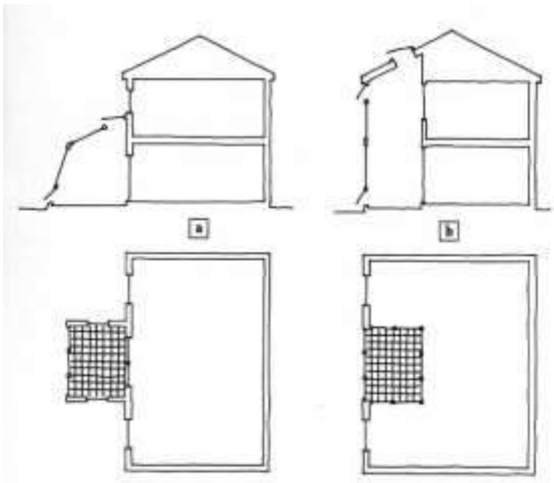


Fig. 50 First generation sunspaces (a) usually protruded from the house. New sunspaces (b) are often two story designs set into a house's south wall

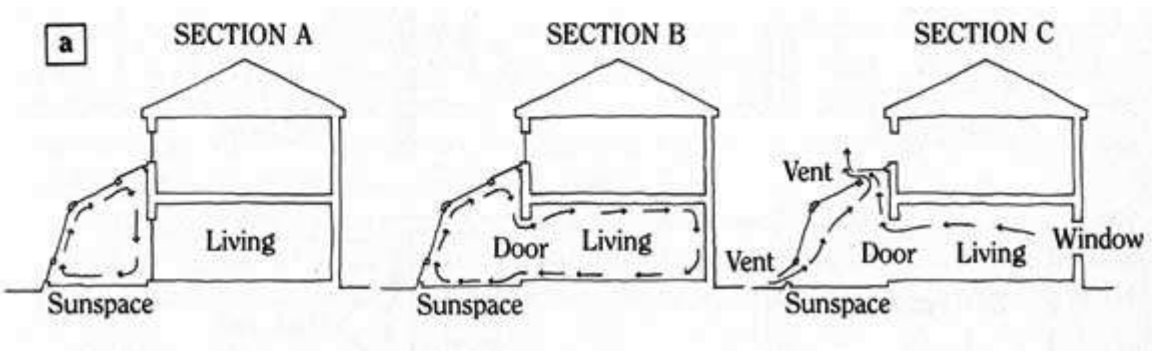


Fig. 51 One-story (attached) sunspaces: winter, thermo siphoning sunspace isolated from the house (Section A); Winter, sunspace helps the lower story via open doors (Section B); Summer, sunspace helps cool the lower story by pulling in air from the north windows (Section C)

A good instance for sunspace can be the garden cabin in London, England (Liddicoat & Goldhill 2012).One of zigzagging facades that angles south towards the sun creates one large south-facing window which maximises natural daylight and passive solar heating to the interior. The garden room is used as a space for both work and entertaining. Also, if we look on the façade of the sunroom, commonly it is whole covered with glass which gives opportunities for good view and lots of possibilities to design you façade in the unique way, using different types of frames and shading.

Fig. 52 The saw-toothed frontelevation which maximises natural daylight and passive solar heating to the interior.

Fig. 53 Interior view of the sun room

Conclusion and main rules:

- A thermal wall on the back of the sunroom against the living space will function like the indirect gain thermal mass wall.
- A well-designed overhang may be all that's necessary to keep the sun out when it's not needed.
- To minimize night time losses and maximize comfort, you may want to include movable window insulation in your design and investigate some of the new high tech glazing.

Conclusion

Passive solar energy is nothing new - if you have ever sat in a car during a sunny day you will have noticed how hot it can sometimes get. About 15% of space heating in an ordinary house comes from solar energy through walls and windows. Passive solar design tries to optimise the amount of energy that can be derived directly from the sun, by careful planning of buildings to collect the sun's heat, thus reducing the need for heating. Similarly careful consideration of building materials and fabric can help to further reduce the need for space heating, ventilation and artificial lighting.

The best part about Passive Solar applications is that they have no moving parts. They can perform effortlessly and quietly without mechanical or electrical assistance. Most design consideration can be made and implemented using standard building materials and basic construction skills. Reductions can be made to heating bills by as much as 40% annually, and also improve the comfort of living spaces. Simple techniques can make a huge difference in the comfort and energy consumption through the years.

Heat and cold control

Reduce air infiltration loss

Air infiltration and humidity entry are things to consider when designing a building. Avoiding air infiltration can reduce energy costs drammatically, while reducing immoderate humidity access helps one avoid various diseases and get hurt by damaged building constructions.

It is important to understand how air exchange works, as well as humidity entry, in order to avoid these problems. Air infiltration happens through not so neat construction work between gaps of exterior and itnerior. Humidity levels in a room can be raised even by breathing or cooking food. As well as through heat bridges through windows or just simply bad roof build.

Considering floor-to-window, wall-to-window ratios, position of heating appliances in a room, even planting a right tree to the right place can reduce heating costs of a building. There are also some German-man made materials that help maintaining appropriate humidity levels.

Reduce air infiltration

Fig. 54 Picture showing the percentage of air that some constructions leak (Major Sources of Air Leaks **(Data source: U.S. Department of Energy)**

Air infiltration is the exchange of air through cracks and gaps in the outside shell of a building. Infiltration increases heating and cooling costs and reduces the comfort for the people living. Loose fitting windows and doors, cracks between the house and the foundation, and gaps around plumbing and electrical penetrations are typical sources of leaks. (The Municipal Art Society of New York 2012)

Mostly air leaks through floors, walls and ceiling, as some gaps might have been missed during the construction; some electric outlets leak air through. Fireplaces are also a common place for the air to leak through since it has a direct access to outside air. Gaps between windows, as well as between doors might provide air infiltration *(Fig 54).*

Fig. 55 Caulking the cracks

Fig. 56 Closing a gap between window frames and outside wall

Reduce air leakage

Reducing air infiltration is often the first action item of a weatherization plan after the energy audit has been completed. Caulking cracks *(Fig 54)*, sealing an unused fireplace, and adding weather-stripping are simple, low-cost improvements that can reduce air infiltration. Caulking should be done with care to ensure that the function of a building element is not impaired. For example, caulking may be added to close a gap between window frames and the outside wall if needed, but not between window sash and the jamb which would prevent the window from opening *(Fig 56).* Instead, weather-stripping can be added to exclude air and allow the sash to operate. (Technical Preservation Services 2014)

Typical places to check for air infiltration are:

- Electrical outlets, switches, ceiling fixtures
- Operable features of windows and doors – check for a loose fit
- Badly fitting windows and doors
- Baseboards
- Fireplace dampers
- Chimney flashing and flues
- Attic hatches
- Wall or window-mounted air conditioners
- Plumbing, electrical, cable, and telephone penetrations
- Ducts in unconditioned spaces

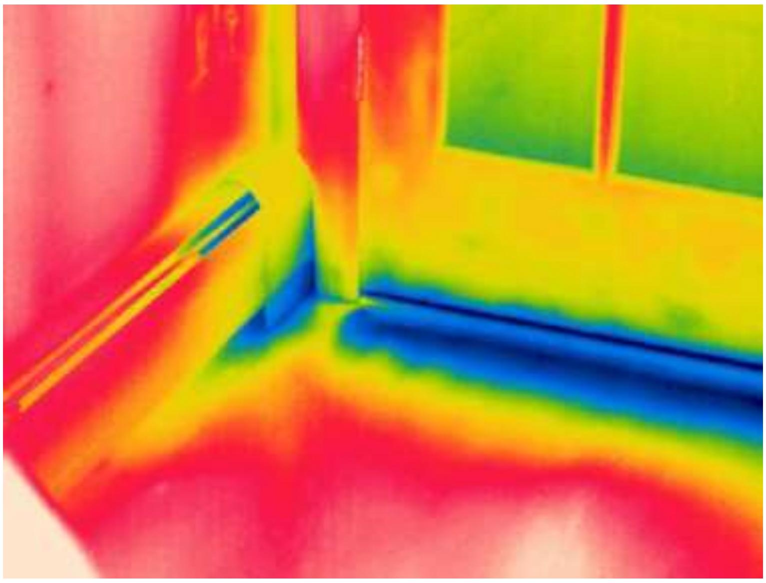


***Fig. 57* Cold air flow seen in blue from the badly fitted doors**

Badly fitting windows and doors *(Fig 57)* are a big contributor to large heating and cooling bills. Solutions are relatively easy and cheap to install. Products including brush seals, foams, sealants, strips and shaped rubber and plastics are cost effective ways of dealing with the problem. (Energy Efficiency Solutions 2011)

All air movement may not be eliminated after infiltration in these areas has been addressed. However, air movement is not necessarily a sign of energy inefficiency, but can be a factor in occupant comfort. It can cause occupants to feel uncomfortable and to assume that energy is being lost. In warmer climates, air movement can make occupants feel cooler, and in cooler climates it can make them feel chilly. If uncomfortable drafts continue after air infiltration has been addressed, consider other options for making interior comfortable with hanging drapery or rearranging furniture placement to avoid the air movement. (Energy Efficiency Solutions 2011)

The consequences of air infiltration are interior performance, excessive energy consumption, an inability to provide adequate heating (or cooling) and drastically impaired performance from heat recovery devices. (Energy Efficiency Solutions 2011)

Conclusion: air leakage cannot be eliminated completely, but can be reduced if one has taken a look at window and door gaps, fireplaces or ducts and taken some actions like ***caulking*** *all those cracks,* ***weather-stripping****,* ***sealing*** *unused fireplaces.*

Position of a radiator in a room

Conventional wisdom seems to tell us that the best place to position a radiator is directly under the window. This will allow the cool air from the window opening to heat before it passes into the room. The cold air would be heading down and the warm air from the radiator would be heading upwards to meet it. This was certainly a good idea when all windows were single glazed to avoid draught. Now that most buildings have double glazing, the heat loss through windows is much less and the draughts coming in have all but disappeared. (Diyfixit 2014)

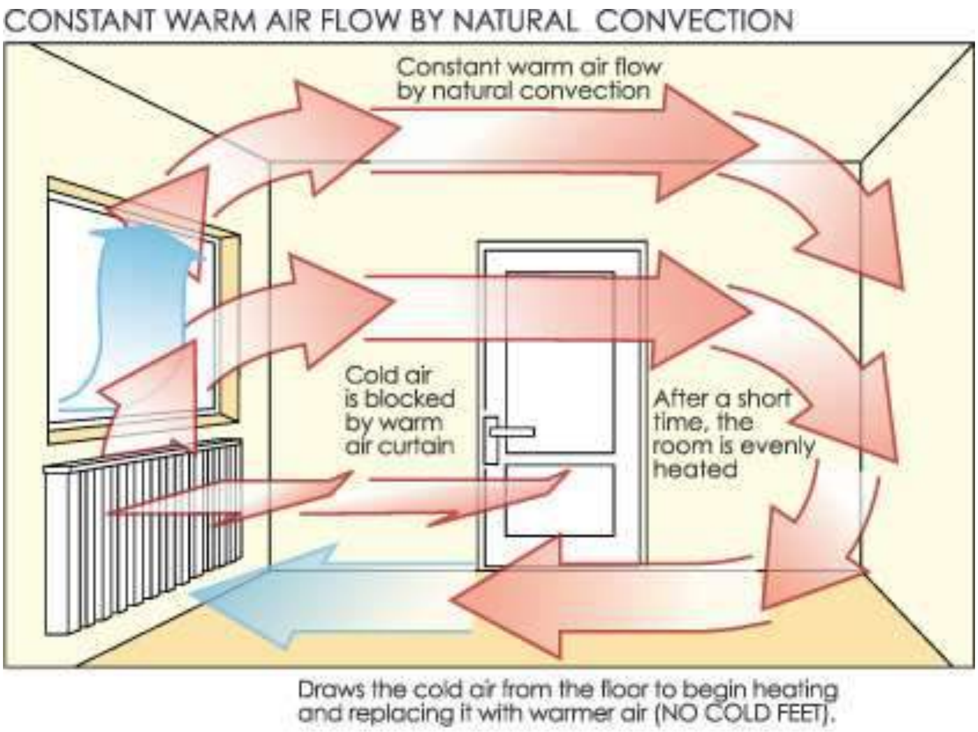


Fig. 58 Even when the windows have double glazing, radiators are being installed under them, which is not the best place because the drafts are no longer that much of an issue

Another reason why radiators might be placed under a window is that they are much less likely to interfere with furniture placement. Most people do not put their couch under the window – due to the draughts – and so the radiator would always be in a clear position. (Diyfixit 2014)

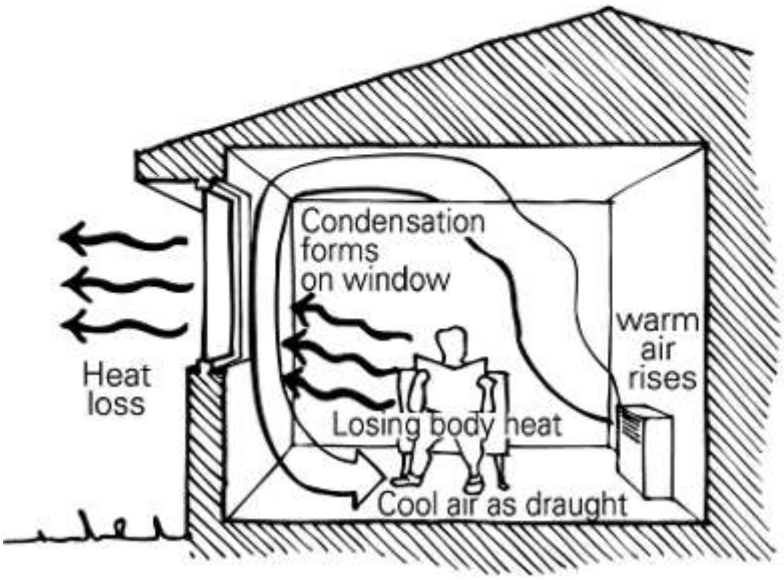


Fig. 59 The worst possible place for a radiator. When a radiator is warming the air, air is going upwards, then goes towards a window, condensate is formed, the person is losing his body heat, heat is lost through the windows, and cold air is flowing through ankles

It is thought that having a radiator on the wall opposite the window is one of the worst places to have it. The cold air will sink to the floor before being dragged across the room to be heated by the radiator and sent upwards. This circulating air can cause cool spots in the room (down the window, across the floor around your ankles, up the radiator and across the ceiling).

Radiators on internal walls will lose less heat than those placed on an external wall. The wall itself will be warmer and the heat absorbed into the wall will be released into the building rather than to the outside. The stored heat will also stay longer and stay warmer. One disadvantage to this is that furniture against the external wall can cause damp issues. Having a radiator on an external wall will prevent the wall from becoming cold or being affected by condensation. (Diyfixit 2014)

Fig. 60 Underfloor heating pipes, before they are covered by the screed

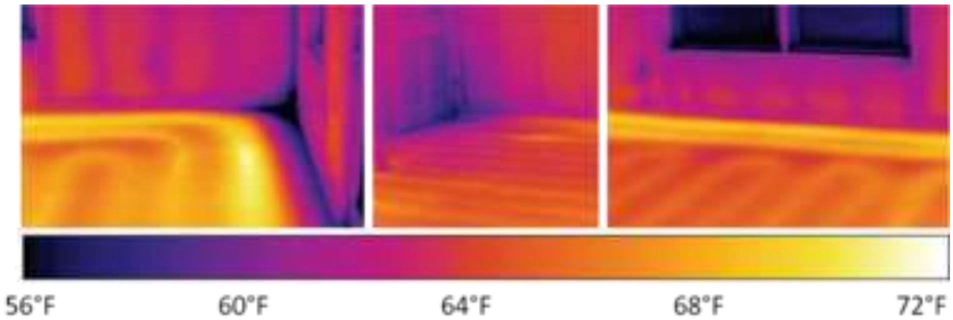


Fig. 61 Thermographic images of a room heated with low temperature radiant heating shortly after starting up the system

Under floor heating offers an effective, efficient heating medium that's out of sight and makes no demands on wall space. It works by effectively turning the entire floor area into a radiator, via warm-water pipes or electric mats concealed within the floor structure. The resulting gentle heat (due to the floor's large surface area, it only needs to be a couple of degrees warmer than room temperature) rises steadily upwards, and there are no cold spots or draughts, making for a very comfortable environment. To add to that, under floor heating is the perfect partner to a heat pump, which is effective at producing the low temperature required. (Home Building 2014)

*Conclusions: one should not be fooled by conventional thinking that radiators should be put under the window. Put them on **internal walls**, or even better – **under the floor** – air circulation will be pleasant and drafts will be avoided.*

FWR (Floor-to-window ratio)

The role of glass in a building's thermal efficiency and comfort is huge. Window size has a major impact of the energy efficiency of a building. Large expanses of standard, clear-glazed windows can make a house uncomfortably hot in summer and hard to keep warm on cloudy winter days and nights. The most appropriate size of windows for smart energy design can be guided by building orientation and amount of thermal mass in the internal building materials. (Build 2014)

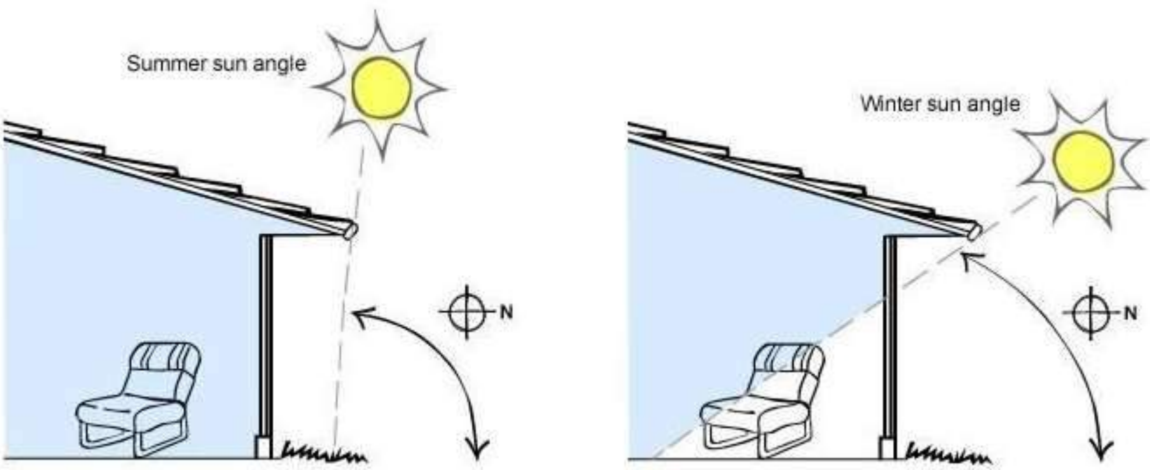


Fig. 62 Showing that summer sun is easily shaded and when needed winter sun is admitted

Thermal mass is the ability of a material to absorb heat energy. A lot of heat energy is required to change the temperature of high density materials like concrete, bricks and tiles. They are therefore said to have high thermal mass. Lightweight materials such as timber have low thermal mass. Appropriate use of thermal mass throughout a building can make a big difference to comfort and heating and cooling bills. Larger areas of glass are better suited to homes with higher levels of thermal mass and larger north-facing windows. A home with less thermal mass, such as timber flooring, should aim to minimise large areas of ordinary glass. As a general rule, keep the total glass area of a house (using ordinary windows) between 20-30% of the total floor area. (Reardon, Thermal mass 2013)

Table 1 Ideal window size based on floor area for standard clear glazing

	Floor material/sun access	Window size as a % of total floor area	Window size as a % of total individual room floor area
North-facing windows	Concrete slab	10-15%	Up to 25%
	Timber	Up to 10%	Up to 20%
	Poor sun access	Less than 8%	Less than 15%
South-facing windows	n/a	Less than 5%	Less than 15%
East-facing windows	n/a	Less than 5%	Less than 15%
West-facing windows	n/a	Less than 3%	Less than 10%

WWR (Window-to-wall ratio)

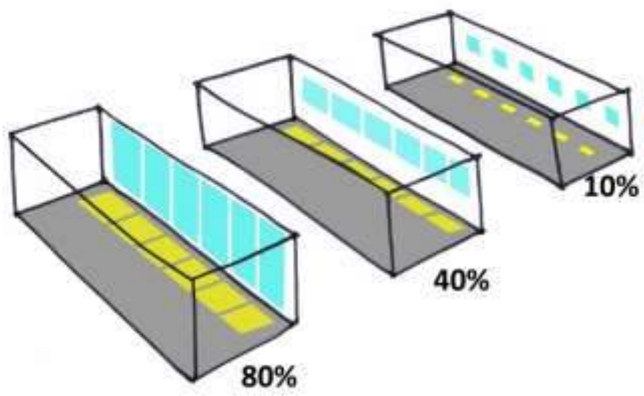


Fig. 63 Different window-to-wall ratios and the resulting illumination

The WWR is a ratio of window (glazing) area to wall area. This relationship can also be expressed as a window to wall percent (or glazing percent). Too high a WWR can result in too much light in the building, creating glare on computer screens and fading upholstery, artwork, printed materials and carpets. It can also contribute to the building being too cold in the winter from the heat lost through windows, and too hot in the summer from all the sunlight and heat coming in.Based on many published strategies for daylighting a building, we found that a whole building WWR = 0.20 to 0.30 ratio of window area to wall area is preferred. An overall WWR < 0.20 does not provide enough daylight, WWR > 0.30 allows too much heat loss in winter and too much heat gain in summer. Our overall WWR comes out to about 0.24, falling into the preferred range to achieve both thermal and daylighting performance.

A common rule of thumb states that the window to wall ratio should be 40% or lower for adequate insulation in cold climates, though more advanced windows with higher R-values (lower U-values) allow higher ratios. In warm climates, higher ratios can be acceptable even without well-insulated windows, as long as the windows are well shaded from the sun's heat.

WWR per exposure

South side: In cold climates, it's recommended that you maximize the WWR on the south side to allow sufficient daylight in with the maximum heat gain in the winter. There is less heat gain from south windows in the summer than there is from east and west windows because of the sun's angle. Our south side is shaded by the building next door, which will further reduce the amount of light and heat entering our building from that side.

North side: It's recommended that you minimize the WWR on the north side because of high winter heat loss through windows on that side. Our north side faces another building, which will further reduce the amount of reflected light coming from that side. The amount of reflected light also depends on the surfaces the light is reflected from and how far the surfaces are from the window. The building adjacent to our north side is very close and has a low reflectance value material (red brick). For these reasons, we chose to reduce the WWR on this side of the building to around 0.16, which will still allow some daylighting from the windows without causing too much heat loss through them.

East and West sides: Because of the angle of the sun, the east and west windows can interfere with the activities inside by introducing too much direct light into a space, which can cause glare in addition to contributing to heat gain issues in the summer. Our east side is shaded by the building next door, so this will not be a problem most times of the year. Our west side faces Second Ave. and is considered the front of our building. Because we are in an historic district, this facade needs to be restored to its original configuration, which was much more glass than the other walls. The WWR for this elevation is around 0.40, 10% higher than the recommended overall WWR, and 20% higher than what's recommended for this elevation in this climate. We have compensated for this by choosing a low solar heat gain coefficient and perhaps adding some internal shades to control the glare and heat gain associated with this high WWR. (Green Garage Detroit 2014)

*Conclusion: Window-to-wall and window-to-floor ratios are calculated so better thermal efficiency can be achieved – keep **WFR to 20-30%**and **WWR to 40% or lower**.*

Using vegetation for buildings

Most people do not realise that simply planting a tree in a right place can result in energy savings. The right tree in the right place provides wind protection, shade, and cool air, while adding beauty, privacy, and wildlife habitat to the landscape.

Deciduous trees (that lose all of their leaves each fall) save energy in summer by shading houses, paved areas, and air conditioners. Small deciduous trees and shrubs, and especially those with low, dense branches, also can serve as effective wind barriers. Large and small evergreen trees and shrubs save energy by slowing cold winds in the winter. They also provide shade, but since they often have branches near the ground, their shade is most effective when the sun is not directly overhead. Both deciduous and evergreen trees save energy in summer by directly cooling the air. This cooling happens as water evaporates from the leaf surfaces, much as our skin is cooled when we perspire. (Kuhns 2014)

Using vegetation as ***shade*** *for buildings*

Fig. 64 (left) Strategic placement of deciduous plants will help when keeping a person cool in summer and warm in winter as trees lose their leaves
(right)A house is surrounded by trees that help managing winds and sunlight

Shade from trees reduces the demand of air conditioning *(Fig 64; 65)*. Planting deciduous trees will create shade for east-facing walls and windows from 7 to 11 a.m. and west-facing surfaces from 3 to 7 p.m. during June, July and August. Trees with mature heights of at least 7 metres should be planted 3 – 6 metres east and west of the house. (Kuhns 2014)

Planting smaller deciduous or evergreen trees with lower limbs northwest and northeast of the building will provide late afternoon and early morning shade. Trees planted to the southeast, south or southwest of a building for summer shade can provide significant cooling and energy savings if properly chosen and located. Such trees must be close enough for some branches to extend out over the roof. Trees must be chosen that will develop single trunks with fairly high, wide crowns and strong branches, such as many oaks, hackberry and Norway maple. Trees with low dense crowns, such as flowering pears,

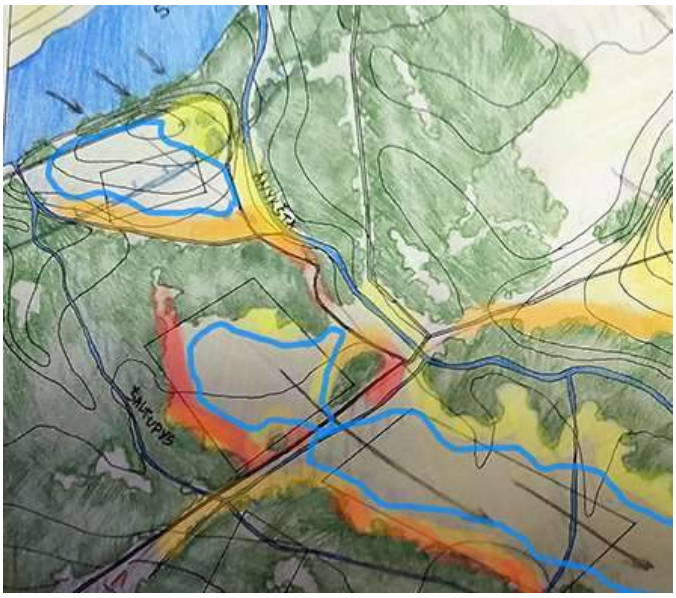


Fig. 65 In this anykščiai site masses of vegetation can be used as shade from intense sun in the afternoon. Blue color indicates space which is mostly lit. Yellow – shade from the morning sun, orange for afternoon and red is for evening.

Fig. 66 Example in Russia of using linear planting or shrubs as shelter from wind

crab-apples, some lindens, and many others, will cast significant shade even in the winter after their leaves have dropped. To avoid winter shading, locate such trees no closer than 2 – ½ times their mature height to the south of a building. Such trees planted to the southeast or southwest should be about four times their mature height from the building. Trees should also be planted to shade paved areas. Light energy striking dark pavement like asphalt is absorbed, causing the air above to be heated. Light coloured pavement absorbs less energy, but can reflect it toward a building. Tree leaves reduce heat and reflection as they absorb light energy and use it to evaporate water. (Kuhns 2014)

Using vegetation as a windbreak

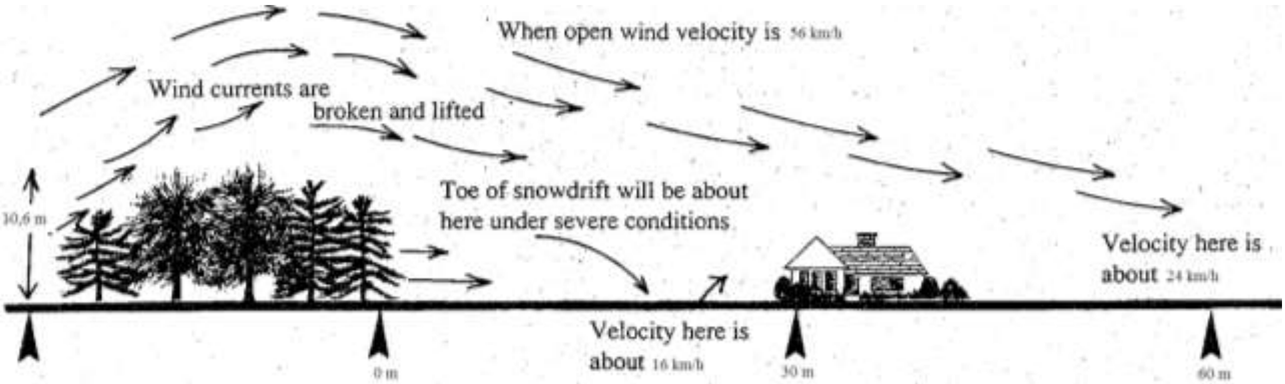


Fig. 67 Using vegetation for wind protection

Trees can reduce energy use for heating by blocking cold winter winds. These winds enter homes through small openings and also carry heat away from the building's outer surfaces. Effective windbreak trees have crowns that extend to the ground and branches that keep their foliage in winter. Junipers, spruces, firs, Douglas-fir, and evergreen shrubs are good choices for wind protection. (Kuhns 2014)

Trees for winter and wind protection should be planted upwind of the area to be protected. This will often mean planting on the west, northwest, and north sides of a building. However, local conditions like mountain ranges may cause prevailing winter winds to be from other directions. Windbreak trees can be planted in straight or curved rows or in linear groupings. They should be close enough together so their crown edges meet within a few years without overcrowding. Small or narrow-crowned trees can be as close as six to eight feet while larger trees can be as far as 4,5 metre apart.*(Fig 66)* Shrubs can be planted as close as ½ - 1 ½ metre apart. (Kuhns 2014)

Windbreaks can consist of one or two dense rows or several less-dense rows. Wind protection extends downwind 10 – 20 times the windbreak height, so the trees need not to be planted close to dwellings to be effective. Snow drifting will be the worst at 2 – 3 times the windbreak height downwind *(Fig 67, Fig 68).* (Kuhns 2014)

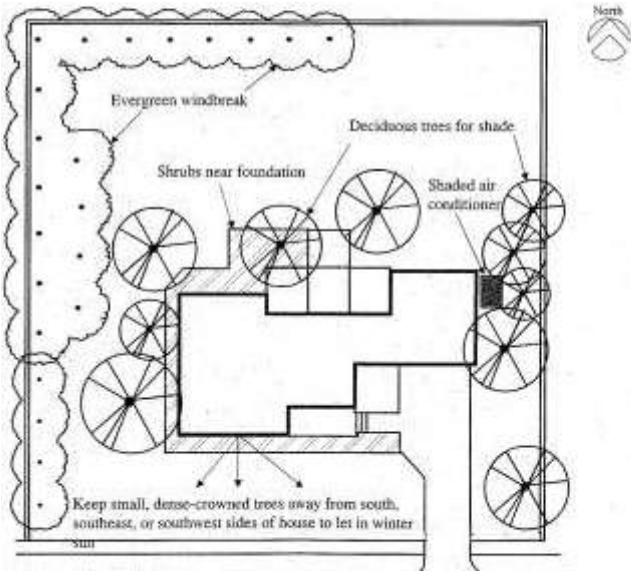


Fig. 68 Scheme for positioning evergreen windbreaks and shades for a house

Planting precautions:

- It's important to learn mature size and crown characteristics of any tree that is being planted. Plants are growing, so they might be too big one day.
- Trees should be planted far enough from sidewalks, driveways, and buildings so the crown can grow. Trees that can readily be pruned as they grow, like most deciduous trees, can be planted closer and allowed to overhang low obstructions.
- Power line location should be taken into consideration. Trees that grow into power lines cause electrical outages.
- Wildfire hazard. In areas where grass, brush, or forest fires are likely, planting trees and shrubs near a building may not be the best idea. Local fire department should be your consultant. (Forestry 2014)
*Conclusion: planting the right tree in a right place can reduce your energy savings – **planting a deciduous tree next to a window** will help managing heat in the summer but will let the sun get through branches in winter. **Evergreen trees and shrubs will break wind** and make the atmosphere cosy and not so cold.*

Heat and humidity in earth-sheltered buildings and positioning of rooms

Positioning of the rooms

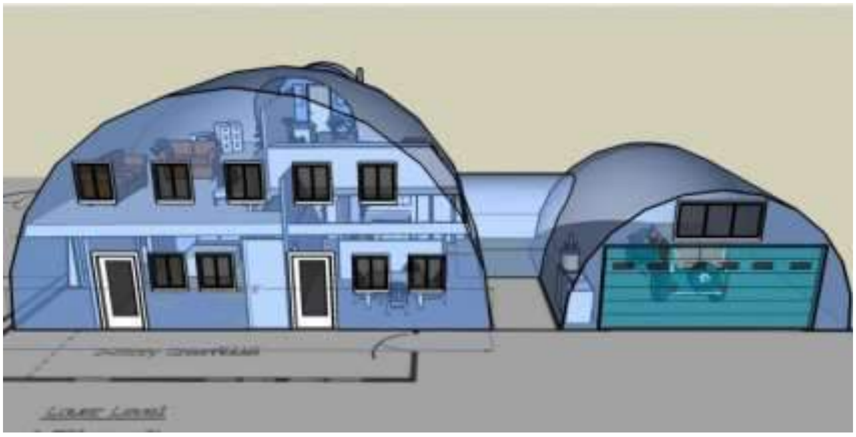


Fig. 69 For beamed or in-hill Positioning of the rooms – rooms like living room, kitchen and bedrooms require sunlight, differently from bathrooms or storage

A common plan is to place all the living spaces on the side of the house facing the equator. This provides maximum solar radiation to bedrooms, living rooms, and kitchen spaces. Rooms that do not require natural daylight and extensive heating such as the bathroom, storage and utility room are typically located on the opposite (or in hill) side of the shelter. *(Fig 69)*This type of layout can also be transposed to a double level house design with both levels completely underground. This plan has the highest energy efficiency of earth sheltered homes because of the compact configuration as well as the structure being submerged deeper in the earth. This provides it with a greater ratio of earth cover to exposed wall than a one story shelter would. (Anselm 2012)

Fig. 70 in this site in Anykščiai wind is coming from the river and the row of trees are immediately blocking it. As we go more to south, there is another tree mass that softens the wind, leaving the space quiet and calm.

With an atrium earth shelter the living spaces are concentrated around the atrium. The atrium arrangement provides a much less compact plan than that of the one or two story beamed/in-hill design; therefore it is commonly less energy efficient, in terms of heating needs. This is one of the reasons why atrium designs are classically applied to warmer climates. However, the atrium does tend to trap air within it which is then heated by the sun and helps reduce heat loss. (Anselm 2012)

Air infiltration

Adequate ventilation must be carefully planned when building an earth-sheltered dwelling.*(Fig 70).* Generally, well-planned, natural ventilation or ventilation by exhaust fans can dissipate ordinary odours. Any combustion appliances that are installed should be "sealed combustion units," which have their own, direct source of outside air for combustion, and the combustion gases are directly vented to the outside. In addition, indoor pollutants emitted by formaldehyde foam insulation, plywood, and some fabrics can accumulate and become an irritant if ventilation is not properly planned. See our section on ventilation for more information. (Energy.gov 2014)

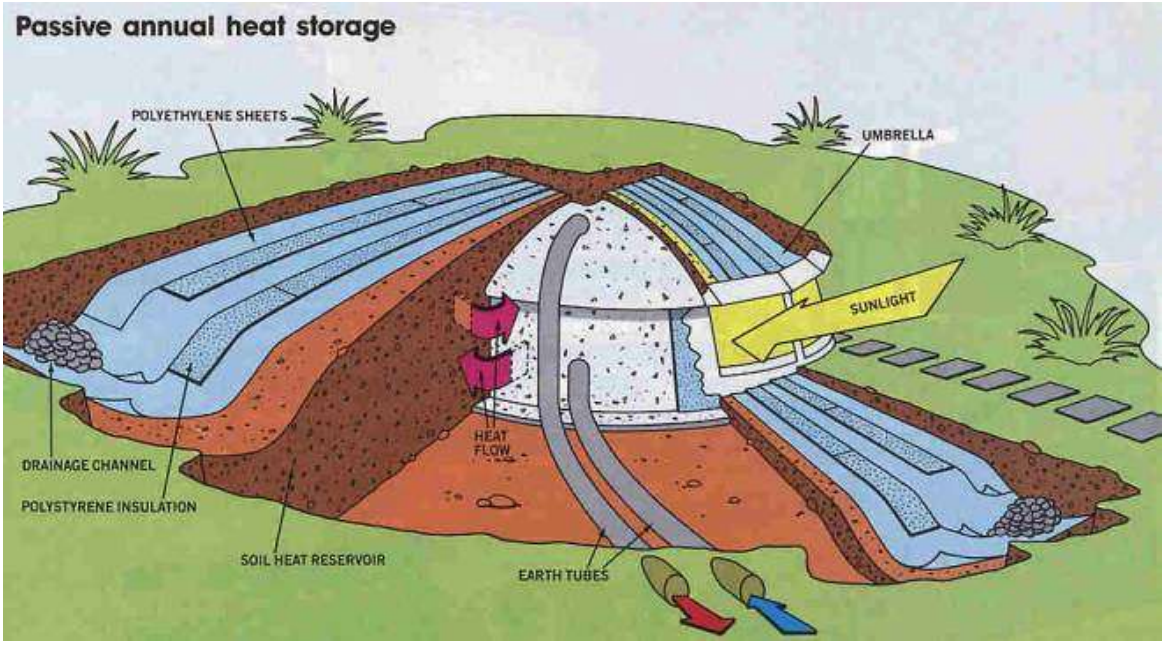


Fig. 71 Passive annual heat storage: showing how heat flow is coming through the earth and how to control humidity in the construction with various materials

Heat and energy savings

Building underground provides energy savings by reducing the early heating and cooling loads in comparison with known conventional structures. Not only is the temperature difference between the exterior and interior reduced, but mostly because the building is also protected from the direct solar radiation. (Anselm 2012)

Potential of energy savings is based on several unique physical characteristics. The first of these characteristics is in the reduction of heat loss due to conduction through the building envelope because of the high density in the earth. In an earth sheltered building even at very shallow depths and given normal environmental conditions, the ground temperatures seldom reaches the outdoor air temperatures in the heat of a normal summer day. This condition allows the conducting of less heat into the house due to the reduced temperature differential. (Anselm 2012)

In the case of colder climates, it was noticed that during winters the rate of heat loss in bermed (earth supported) structure was less in comparison to that in on-grade structures. This indicates through results that the floor surface temperature increased by 3^{O} C for a 2 metre deep bermed structure due to lower heat transfer from the building components to the ground, thus suggesting the presence of passive heat supply from the ground even at the extreme cold temperatures of winter. (Anselm 2012)

What is more, air infiltration is reduced. Within the dwelling which is mainly surrounded by earth walls with very little surface area, there is not much exposure to the outside air.

Waterproofing

Waterproofing can be a challenge in earth-sheltered construction. Keep in mind these three ways reducing the risk of water damage in your house: choose the site carefully, plan the drainage both at and below the surface of the house, and waterproof your house. (Energy.gov 2014)

There are several waterproofing systems currently in use, including rubberized asphalt, plastic and vulcanized sheets, liquid polyurethanes, and bentonite. Each has its advantages and the one you choose will depend on your site and house plan. (Energy.gov 2014)

Rubberized asphalt combines a small amount of synthetic rubber with asphalt and is coated with a polyethylene layer to form sheets. It can be applied directly to walls and roofs and has a long life expectancy. Plastic and vulcanized sheets are among the most common types of underground waterproofing. Plastic sheets include high-density polyethylene, chlorinated polyethylene, polyvinyl chloride, and chlorosulfonated polyethylene. Suitable vulcanized membranes or synthetic rubbers include isobutylene isoprene, ethylene propylene diene monomer, polychloroprene (neoprene), and polyisobutylene. For all these materials, the seams must be sealed properly, or the membranes will leak. Liquid polyurethanes are often used in places where it is awkward to apply a membrane. Polyurethanes are sometimes used as a coating over insulation on underground structures; however, weather conditions must be dry and relatively warm during their application. Bentonite is natural clay formed into panels or applied as a liquid spray. The panels are simply nailed to walls; the spray is mixed with a binding agent and applied to underground walls. When the bentonite comes in contact with moisture, it expands and seals out the moisture. (Energy.gov 2014)

Fig. 72 **Bentonite waterproofing being sprayed on a home recently completed in Missouri**

Humidity

Humidity levels may increase in earth-sheltered houses during the summer, which can cause condensation on the interior walls. Installing insulation on the outside of the walls will prevent the walls from cooling down to earth temperature; however, it also reduces the summer cooling effect of the walls, which may be viewed as an advantage in hot temperatures. Mechanical air conditioning or a dehumidifier is often necessary to solve the humidity issue. Proper ventilation of closets and other closed spaces should keep the humidity from becoming a problem in those areas. (Energy.gov 2014)

*Conclusion: having an earth-sheltered building construction reduces air infiltration, as most of the exterior is surrounded by earth, humidity might be the issue, but when selected sustainable materials such as **bentonite**, can be solved.*

Humidity issues in conventional buildings that are above the ground are different than in beamed or in-hill constructions. In the second part, condensation and humidity levels will be discussed.

Avoid humidity entry in the building

Condensation

Condensation occurs in a building when moist air comes into contact with a surface which is at a lower temperature. Moist air contains water vapour – commonly referred to as humidity.

Condensation forms first on the coldest surfaces of a room, usually on glass surfaces of windows and doors. These surfaces are typically cooled by lower exterior temperatures during the winter months much more easily than the walls which are kept warm by insulation. A small amount of condensation appearing on a surface may not necessarily be a problem, depending on the amount of moisture that forms, how long it stays, and whether it accumulates on surfaces that can be damaged by water. Condensation can be short-term during a severe cold spell, or occur in a localised area such as kitchen, bathroom or laundry room. (Homeowner Protection Office 2014)

In many instances, condensation moisture simply evaporates back into the air once the surfaces warm up or the moisture source is reduced. An example of this is moisture that condenses on a bathroom window during a shower and quickly disappears shortly after the shower is turned off.

Ways humidity enters the building

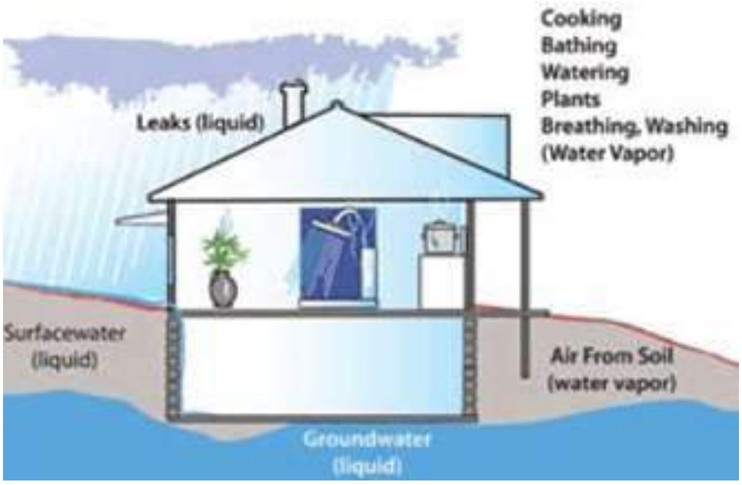


Fig. 73 Demonstration how humidity formed in building

- Rainwater intrusion. Moisture present in building materials and on the site during construction can be a source of problems. Significant amounts of moisture can also result from water leaks within building systems or through the building envelope. In hot, humid and temperate climates, rainwater leaks are a major source of building moisture and fungal growth problems.
- Infiltration of outside moisture-laden air. Infiltrated humid air, whether introduced by wind or through the HVAC system, can cause condensation on interior surfaces, including inside building cavities. Condensation and high relative humidity levels are important factors in creating an environment conducive to mould growth and are the primary problems in hot, humid climates. The issue of infiltration caused by negative pressure of the building created by HVAC systems is detailed in HVAC Design and Construction in Humid Climates.
- Internally generated moisture. After construction, occupant activities and routine housekeeping procedures can generate additional moisture, contributing to the mould problem. Normally, if no other significant sources exist, well-designed and properly operating HVAC systems can adequately remove this moisture.
- Vapour diffusion through the building envelope. Differential vapour pressure, which can cause water vapour to diffuse through the building envelope, is a less significant cause of moisture problems in buildings in hit humid climates. However, it can be a significant moisture movement mechanism, particularly in cold climates, and especially as it relates to wall system vapour retarder construction. (Etter 2014)

Problems caused by condensation

Condensation can cause serious damage to the interior and structural elements of a building. If condensation occurs frequently enough and for prolonged period of time, materials in contact with the moisture may be damaged. (Homeowner Protection Office 2014)

Drywall and wood finishes around windows are two examples of materials in a building that can readily absorb moisture and become damaged if they remain wet for a sustained period of time. If left, unchecked, condensation problems can cause:

- Crumbling or soft spots in drywall
- Decay in wood framing or corrosion of steel framing

- Peeling paint *(Fig.74)*
- Damage to the insulation inside the walls
- Mould and mildew problems in a building *(Fig. 75*) (Homeowner Protection Office 2014)

Fig. 74 Peeling paint

***Fig. 75* Roof construction damage by mould**

Controlling humidity

Internal humidity can be controlled by:

- Passive ventilation by opening windows for cross ventilation*(Fig. 76)*
- Removing moisture at source, for example, using an extract fan in the bathroom, using a range hood *(Fig.77)* in the kitchen, venting a dryer to the outside and using only externally vented gas heaters
- Raising indoor temperatures by heating or insulating*(Fig.78)*, since warmer temperatures imply lower relative humidity (Level 2014)

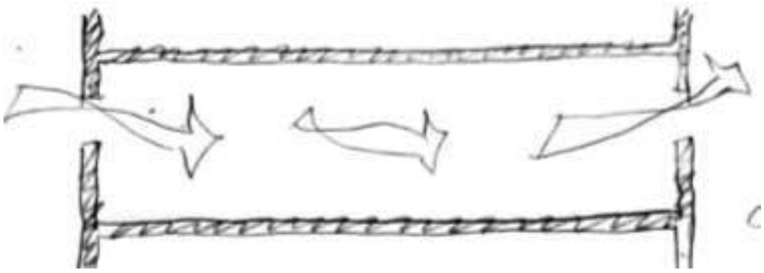


Fig. 76 Cross ventilation is helpful when reducing overall humidity in the room

Fig. 77 Installing a rangehood in a kitchen sucks in the moisture from cooking

Fig. 78 Higher temperatures usually mean less humidity – installing an insulation in wall heightens the temperature and makes humidity lower

To prevent moisture from the space under a floor getting into the building and increasing the levels of internal moisture:

- Ensure there is good ventilation under suspended timber floors – clear openings of 3500 mm^2 per square metre of floor area must be provided
- Cover the ground with a vapour barrier such as polyethylene sheet where there is high ground water content under the building or where sufficient under floor ventilation cannot be provided. (Even with a vapour barrier, minimum subfloor ventilation openings of 700 mm^2 per square metre of floor area must still be provided.) (Level 2014)

The most effective passive ventilation to remove internal moisture is simply to open windows. These should preferably be on opposite sides of the building to maintain a good cross air flow.

Vents in window frames allow air movement while maintaining security when the house is closed up. The recommended minimum vent area is 4000 mm^2 of air opening per room space for an average size room. This can be achieved by a 600 mm long vent in a window frame. (Level 2014)

*Conclusion: humidity entry can be prevented by having a good roof **construction**, **range hood** being installed in the kitchen, proper **insulation** in the walls and routinely **ventilating** the rooms.*

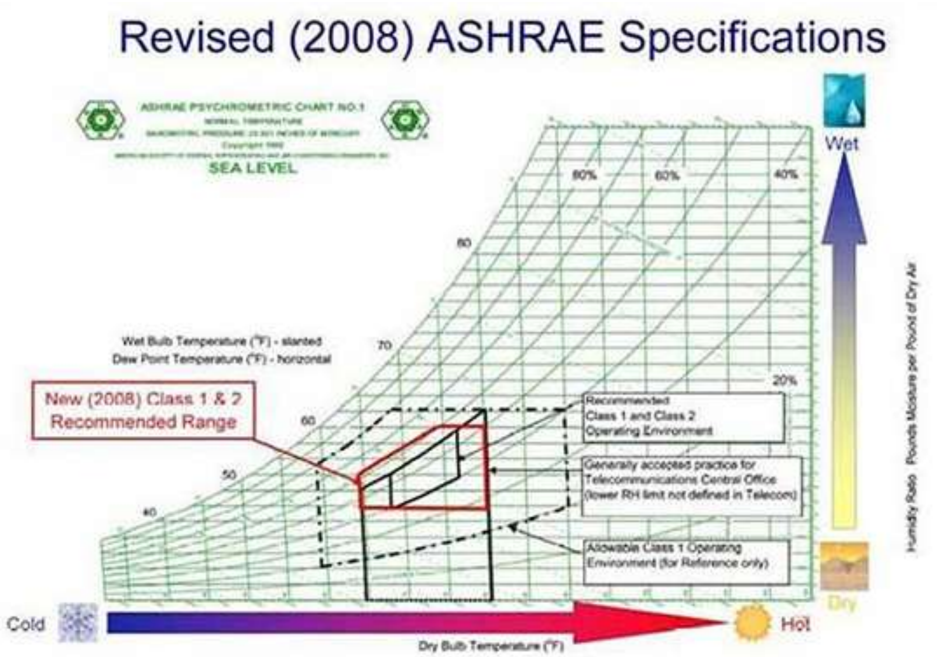


Fig. 79 ASHRAE specifications for appropriate humidity and temperature

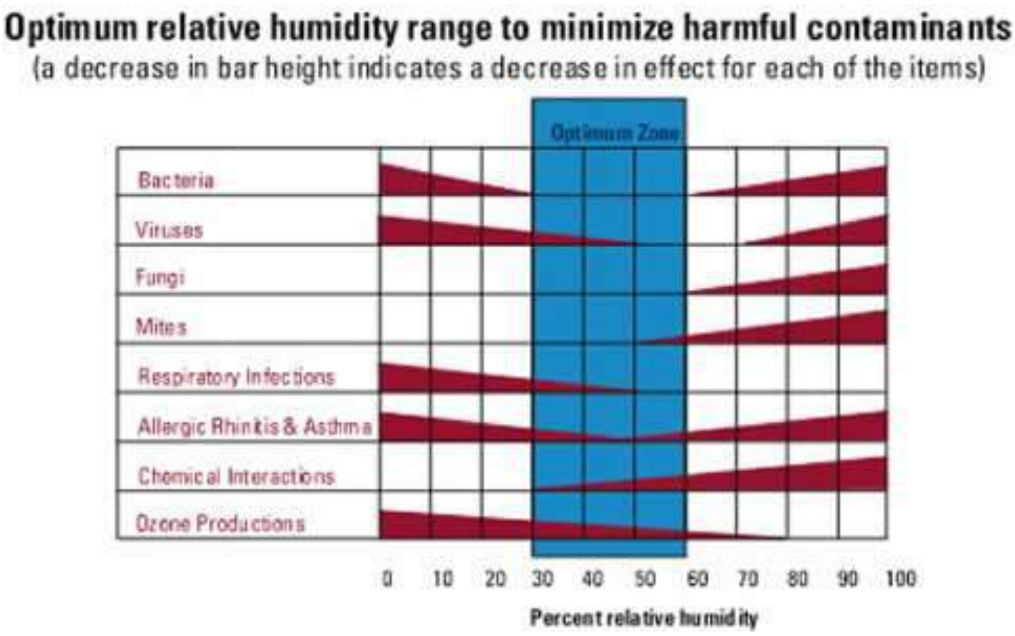


Fig. 80 Too little humidity induces chronic physical symptoms like sore throat, dry skin, sinus irritation, can contribute to static build-up leading to painful static shocks. Moreover, it makes you feel colder regardless the temperature and can cause wood furniture, woodwork and plaster to crack or split. Though too much humidity can make you feel clammy, sweaty or sticky, cause warping in wood, peeling of paints and wallpaper, and mildwe in paper-based materials. It also increases allergens like dust mites, moulds and fungi, which thrive at higher humidity levels.

The recommended relative humidity level varies between winter and summer, and by location. As a rough 'rule of thumb', interior air temperatures should generally be maintained between 18^{O}C and 24^{O}C with relative humidity falling between 35% and 60% for the coastal temperature climate regions. During the winter months in colder and drier regions of the province, interior humidity levels should be limited to between 25% and 40%. A maximum indoor relative humidity of 55% RH may be acceptable, 50% RH is better, 45% RH is best. Humidity cannot be eliminated from the air altogether. It is needed to maintain a comfortable and healthy interior environment. Without humidity we would suffer from chapped lips and dry skin, breathing problems, static electricity and etc.

*Conclusion: it is important to know that humidity and temperature are huge factors in human comfort – a human feels most comfortable between **18 to 24** degrees Celsius,, humidity should be about **45%.***

TecTem materials

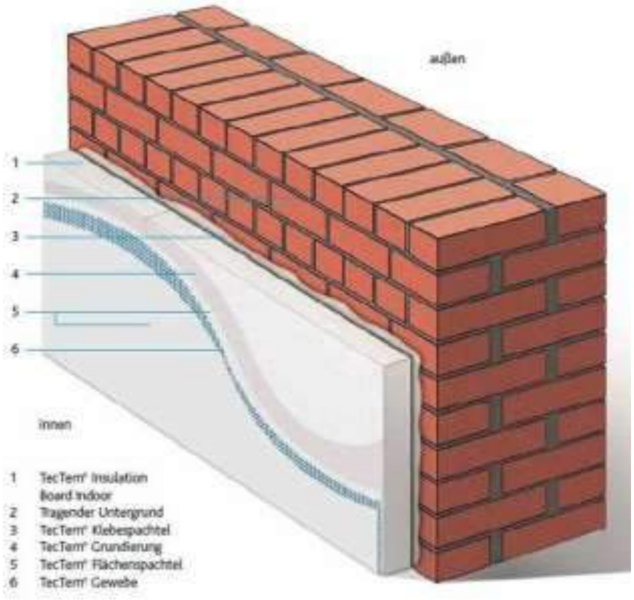


Fig. 81 Use of TecTem

Recently Knauf created a system 'TecTem' that is perfectly suited to insulate from inside all sorts of rooms and accommodation, no matter what exterior walls are made from – if they're masonry or light or heavy concrete, or mixed with clay. Their thermal conductivity is λ=0.045 W/mK. This system is not only good for it's warmth properties, but it also keeps a positive microclimate and secures comfortable and healthy atmosphere – it regulates the climate in the room and maintains proper humidity. (Karka 2014)

'TecTem Insulation Board Indoor' are made from natural perlite and mineral bonders. They are capillary-active, thus absorbing condensation that has occurred because of the dew point on the exterior construction internal side and later gradually carrying it to both exterior walls (absorbing) and interior (evaporating it to inside room). It is scientifically proven that insulating a building this way exterior wall surface temperature exceeds the critical point, consequently there's no reason for condensation to form, which guarantees no mildew. (Karka 2014)

‘TecTem’ is made from natural ecological materials. They are resistant to mould and fire – it belongs to A1 class materials that are inflammable. (Karka 2014)

Conclusion: if Germans rely on this, why others would not – TecTem is a great material to maintain human comfort in a room, with its capillary-active characteristics.

Conclusion

Air leakage cannot be eliminated completely, but can be reduced if one has taken a look at window and door gaps, fireplaces or ducts and taken some actions like caulking all those cracks, weather-stripping, sealing unused fireplaces. What is more, one should not be fooled by conventional thinking that radiators should be put under the window. Put them on internal walls, or even better – under the floor – air circulation will be pleasant and drafts will be avoided. Ratios like window-to-wall and window-to-floor are calculated so better thermal efficiency can be achieved – keep WFR to 20-30% and WWR to 40% or lower. Considering the nature’s role in designing, planting the right tree in a right place can reduce one’s energy savings – planting a deciduous tree next to a window will help managing heat in the summer but will let the sun get through branches in winter. Evergreen trees and shrubs will break wind and make the atmosphere cozy and not so cold. Other solution is considering having an earth-sheltered building. The construction itself reduces air infiltration, as most of the exterior is surrounded by earth, humidity might be the issue, but when selected sustainable materials such as betonies, can be solved. In conventional buildings, humidity entry can be prevented by having a good roof construction, range hood being installed in the kitchen, proper insulation in the walls and routinely ventilating the rooms. But it is important to know that humidity and temperature are huge factors in human comfort – a human feels most comfortable between 18 to 24 degrees Celsius,, humidity should be about 45%. What is more, TecTem is a great material to maintain human comfort in a room, with it’s capillary-active characteristics. When having in mind all these bioclimatic design principles one can feel like truly living with architecture that is sustainable without all unnecessary expensive gadgets, but using physics and nature aid instead.

Reduction of transmission loss

Reducing heat transfer is one way of improving energy efficiency. Sometimes we want to keep things cool. In summer we use air conditioners to keep our homes and offices cool and comfortable. Electrical energy is saved if heat entering our rooms are minimized by good insulation. The amount of heat loss in your home can help the environment, and it can save you a lot of money. Some heat loss reduction methods may require an investment, but it will be worth it when the electric bill comes (Energy efficiency by reducing heat transfer 2012)

External surfaces

External Wall Insulation is a modern and advanced method that is estimated to save buildings losing 45% of their heat, mostly those that are constructed from brick, solid masonry, and concrete. With different systems of building materials which were mentioned before heat loss can change properties of carbon emissions and save energy costs, prolonging the life of existing properties, all of which is essential for our health and financial issues in our current environmental and economic climate. (External Wall Insulation , 2011)

Reducing Heat Lost Through Walls

Timber-framed Walls

Timber-framed construction is the preferred type for houses in Scandinavia and North America. They often differ little in outward appearance from traditional walls, owing to the brick outer leaf that is often applied.

Many dwellings built before 1976 had very low standards of insulation, which may now be in poor condition. Insulation can be added quite easily, but the process can be very disruptive to householders, and is best carried out during major refurbishment. However, timber-framed houses built after 1976 are fairly energy-efficient because of the technological advancement and the better quality of materials. (Reducing Heat Lost Through Walls, n.d.)

Thermal conductivity of prefabricated timber frame wall (typical density 460–480 kg/m2) = 0.12 W/m·K(Anderson)

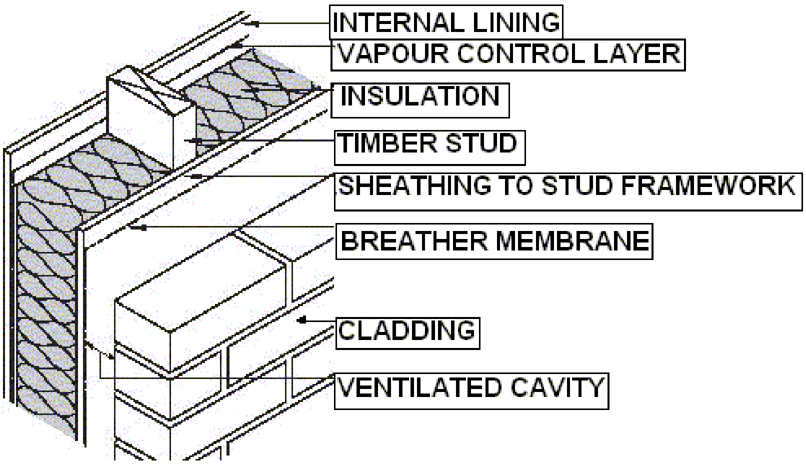


Fig.82 Timber framed wall

Solid Walls

Mostly constructed of brick, solid walls can also be built of stone or concrete. Solid walls are mostly less than 25 cm thick, although sometimes in older properties they are over 33 cm thick.

Heat loss through these walls is generally high, but they can be insulated internally or externally. To insulate solid walls internally, insulation boards to the walls can be fit. This is otherwise known as dry lining. It involves fixing insulation material to the inner side of a solid external wall, and then covering it with plasterboards or cladding. To insulate solid walls externally, a layer of insulation material needs to be fixed to the walls with adhesive, then covered with cement or cladding. Both will change the appearance of your house externally, so this is less appealing than insulating internally for many home owners. (How can I insulate my house if I don't have cavity walls n.d.) The thicker the board the more effective it will be in insulating the house, but if the walls are too thick, it can be impractical as it reduces the amount of floor space in a room. Most boards are around 100mm.

Applying insulation to solid walls is usually only considered cost-effective as part of major works to repair existing walls, such as repairs to plaster or to the exterior. Your builder can advise you about insulation, if you decide to repair your solid walls. (Reducing Heat Lost Through Walls, 2010)

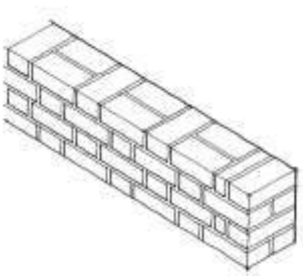


Fig. 84 Solid brick wall

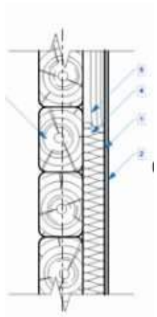


Fig. 83 Log wall

Log Walls

In many countries (such as Baltic or northern countries), simple log walls do not fulfil today's energy efficiency demands without an additional insulation layer. To add this layer, put up a timber frame with insulation on either the inner or outer side of the log structure. Design the studding so that log wall can settle normally. Thermal conductivity of a log wall 120 mm = 0.12 W/mK (Log Walls, 2010)

Eco friendly materials

Building insulation materials are thermal insulation materials used in the construction to reduce heat transfer by conduction, radiation or convection and are employed in varying combinations to achieve the desired outcome (usually thermal comfort with reduced energy consumption).

Fig. 85 Greenloft material

Greenloft is an Ofgem approved, flexible, low density, high performance thermal insulator designed primarily for loft insulation. It is made almost entirely from waste plastic bottles, providing a high performance eco-friendly alternative to more traditional mineral wool insulation. 200mm of Greenloft reduces heat loss by up to 90% through the ceiling compared to an insulated loft. Greenloft performs extremely well both thermally and acoustically and, unlike mineral wool insulation, it is non-irritant and there are no floating fibres that could potentially be inhaled. Environmentally, Greenloft not only helps to save energy in use it also helps to reduce energy consumption in its manufacture because it is made from recycled materials. (Thermal Insulation, 2010.)

Fig. 86 Steico Canaflex

SteicoCanaflex hemp fibre insulation material is an excellent building heat insulator. Flexibility of the material allows it to be conformed to surface while at the same time providing durability and longevity without losing quality. By choosing SteicoCanaflex as insulation material, you will obtain great result, excellent quality and reliable service for years to come. Natural hemp fibre will provide breathability of insulated surface as well as moisture regulation thus providing healthy and pleasant micro-climate indoors.

Effect after material deposition: heat insulation, acoustic insulation, moisture regulation indoors, healthy micro-climate and cosiness. (STEICO Focus on Healthy Fabric,2007)

Building geometry

Building geometry is an important factor to consider from a design standpoint. It influences heat loss, heat gains, infiltration, and solar gains which influence the heating and cooling load. Typically, the more wall (including windows) area available, the higher the heating and cooling loads. (Compact Building Form Cuts Heat Loss, 2009)

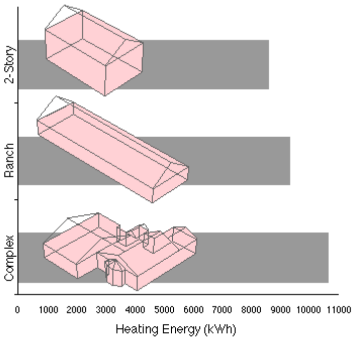


Fig.88 Building geometry comparison

Components	2-story	Ranch	Complex
Ceiling	1000	2000	2053
Wall	2210	1680	1941
Floor	1000	2000	2000
Volume	17000	16000	17250
Surface Area	4210	5680	5994
Heating Energy	8580 (kWh)	9300 (kWh)	10640 (kWh)
Heating Cost			
$0.05/kWh	429	465	532
$0.09/kWh	772	837	958
$0.13/kWh	1115	1209	1383

Fig. 87 Building geometry prices

The key difference between the designs is the surface area of the building's thermal envelope. The compact two-story design has 185 sq. m. of surface area-30 percent less than the complex, one-story design and 26 percent less than the ranch. More surface area means more heat loss. The complex design requires up to 24 percent more energy for space heating. As these examples show, building form has a major impact on heat loss. That doesn't mean every house should be a two-story rectangle. But it does suggest that simplicity can save energy (as well as construction costs). One good tool for making design decisions is a computer program that estimates energy use. Several good energy analysis programs are available. (Compact Building Form Cuts Heat Loss, 2007)

Optimal insulation

Heat has a tendency to rise, it also has a tendency to flow to the coldest point until the temperature becomes even. To stop this flow we use things such as walls, ceilings and floors, however the materials that they are made of are not necessarily the best insulators so we add insulation to them. We are trying to stop or at the very least reduce thermal transmission. This is the flow of heat or cold.

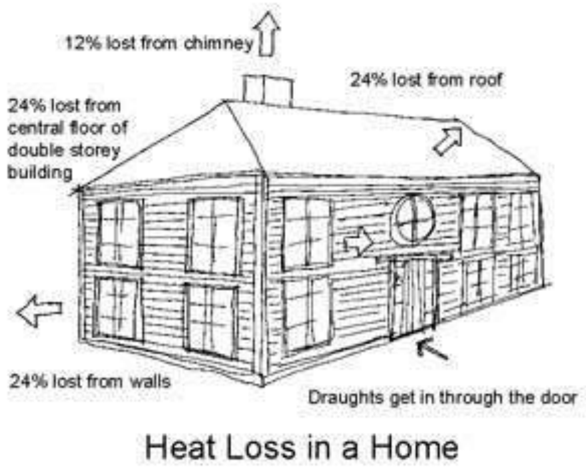


Fig.89 Ilustration showing main heat loss points

To stop this thermal transmission we use items that have a high R (thermal resistance) rating or in layman's terms insulation. Generally the higher the R rating the higher the insulation value. The amount of heat we lose in a home that isn't insulated is (up to) approximately as follows:

Chimney 12 %
A central floor to a double story building 42 %
Walls 24 %
Roof 24 %

Considering that 54% of all energy that goes into the home is for heating then any savings we can make in this area can save you quite a bit of money.

A very easy way is to stop as many drafts as possible. Not only will that make your home feel more comfortable but also stops the warm air escaping. Of course we still need fresh air and ventilation but things like drafts through doors and windows are easily fixed with either mastic sealants (these are the liquid forms of often silicon based products that get squeezed into gaps and when dry feel rubbery), sticky backed foam tape (which comes in rolls and you cut it to length and stick it to the edges of a door or window opening to help seal it). (House Insulation, 2012.)

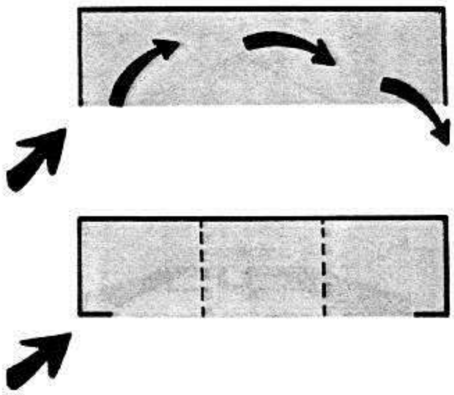
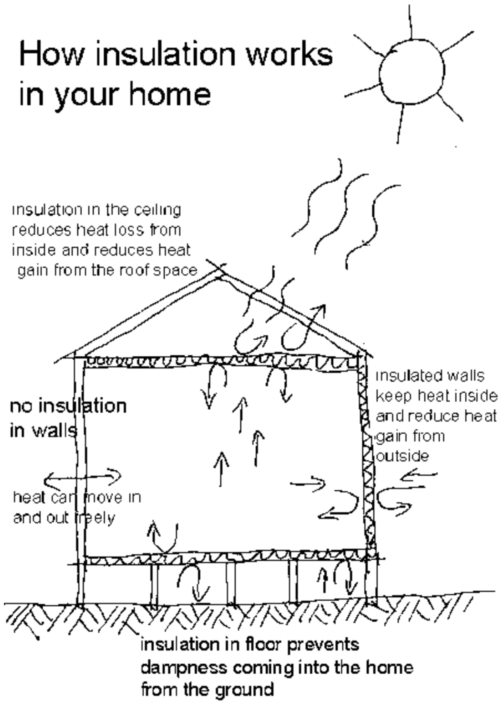


Fig.90 Way of stopping drafts

Wind blowing against an end wall creates drafts If the air can enter the upwind end and travel the length of the building without obstruction. These drafts can be controlled by corner



extensions, partitions and swirl chambers. *(Natural Ventilation for Livestock Housing, 2009.)*

Fig. 91 Insulation in a house

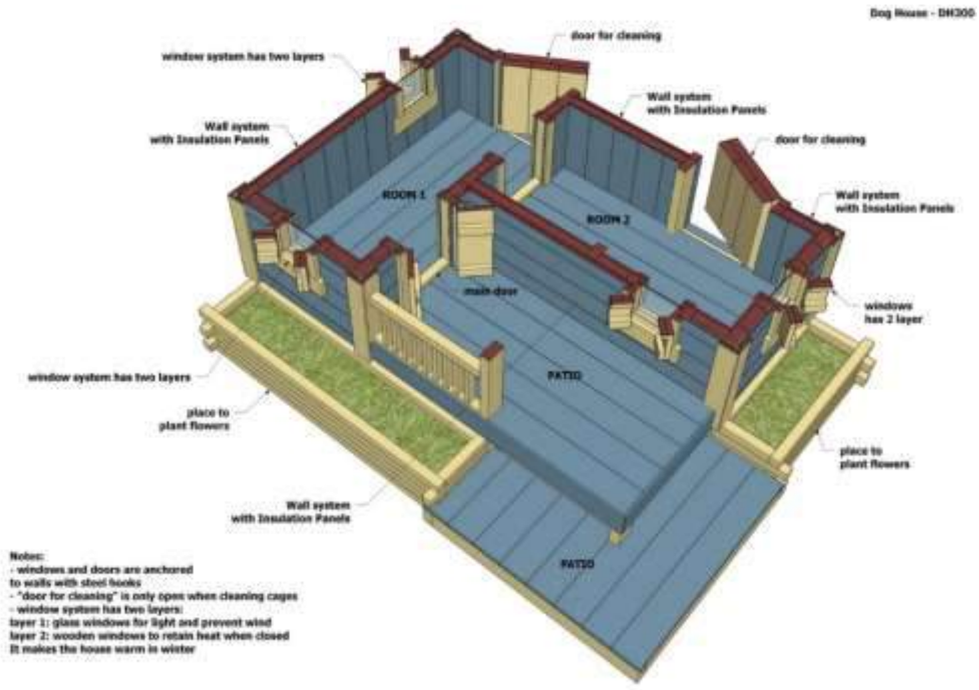


Fig.92 Insulation work in a house

Although heat rises, when a space such as the attic gets to be full of hot air the heat will naturally radiate in all directions, especially when the air is hotter in the attic than in the house. Remember that heat will flow to the cold. What the fiberglass insulation does is creates a thermal barrier between the attic space and the living spaces below. Plaster board doesn't do this effectively but does stop air movement.

Fig. 93 Shutters

Fig. 94 House in Miramar / e|348 Arquitectura, Portugal

The difference between double glazing and single glazing over the total cost of glazing to a home is not a great deal and you will be surprised by the amount of money it saves you and the quality of life in your home that it brings.

Modern double glazing is now often filled with an inert gas in the sealed area between the panes of glass. This helps with the insulation properties of both heat transfer and to an extent, sound. It reduces solar gain in the summer as well as heat loss in the winter. (House Insulation, 2011.)

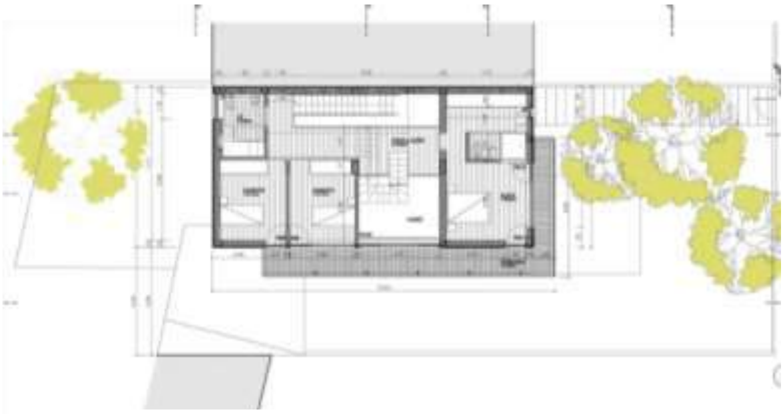


Fig. 95 House in Miramar 348 Arquitectura, Portugal, plan

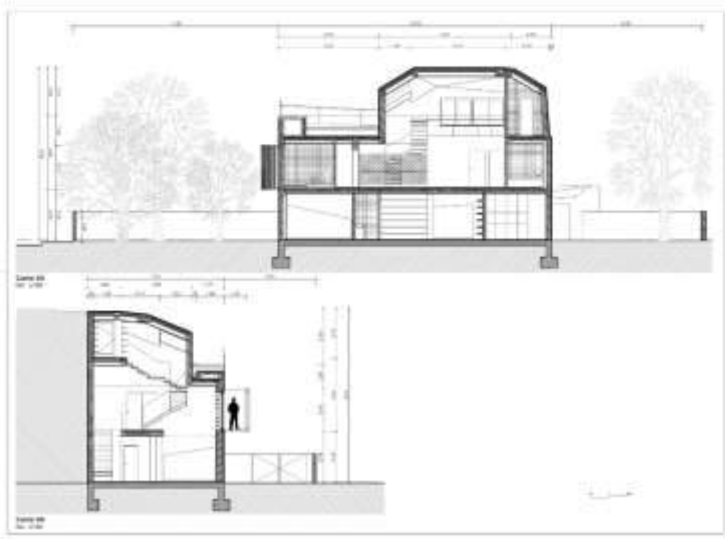


Fig. 96 House in Miramar / e|348 Arquitectura, Portugal, section

Another method of double glazing is to actually double window. This was a very common method in the buildings in Europe. The double windows do the same job as the double glazing but in the summer the second set of internal windows are kept open. The other advantage of double windows to a building is that they are very good sound insulators if the gap between them is 4 to 6 inches or more. As an interior designer another way of achieving this system is to use bi folding shutters to the insides of the windows. This is particularly suited to older and rustic homes. (Architects)

Reducing Under Floor Drafts

If you are able to get under the house i.e. it is built on piles with a crawl space or has a basement, then using a fiberglass blanket under there or polystyrene sheets between the joists is very effective too. Because wind can get under a house it is important to strap these items in place to stop any movement.

Window shades to the exterior of the building will help with reducing solar gain to the building through the glazing and reduce the use of air conditioning in those hotter parts of the world. (House Insulation,2011.)

Higher thermal inertia

Not only can the heating requirement be lowered by increasing thermal inertia in buildings, but also the need for cooling. This can become more and more important with an increasing interest in low energy buildings and the potential problem with overheating in the summer. One method making use of heavy constructions already used today in many offices and larger buildings, mainly to reduce the cooling load, is by using hollow core concrete slabs as ceilings/floors in buildings *(Fig.97)*. In summer the slabs are cooled during the night using cold outside air and during daytime the ventilation air passes through the hollows thus being cooled down before entering the room. At the same time excess heat from people and equipment can be absorbed into the slabs. In the winter excess heat during the day is stored in the slabs to be released during the night, lowering the need for space heating after office hours. (Gawin) (The effect of wall thermal capacity and thermal resistance in the energy efficiency of small office, 2010)

Historically, many ancient civilizations erected buildings that happened to have high thermal inertia. In places with high daily amplitude of air temperature and intense solar radiation, buildings made of heavy elements with high thermal capacity showed improved interior thermal environment conditions. Due to environmental concerns, recent studies have taken up this concept, indicating its potential in improve thermal comfort while reducing energy consumption in HVAC in small buildings exposed to various different weather conditions. Other studies have also revealed the main factors affecting building thermal inertia. One that stands out is the position of thermal insulation in the building envelope, which provides different thermal responses of buildings for the same value of thermal resistance. (G. S. Barozzi)

The left thermal image shows the walls of this building before insulating. After insulation was added, the cooler and, thus darker exterior walls evidence how much the heat loss has been reduced.

Fig. 97 Thermal photo of a building

Fig.98 Stone wall

Stone walls with substantial mass have high thermal inertia.

Fig. 99 New Englan house

A typical New England saltbox features a steeply sloping roof to shed snow and a floor plan organized around a central chimney to conserve heat. (Improving Energy Efficiency in Historic Buildings, 2012)

Phase change materials

PCM are suitable materials characterized by the fact that, at the atmospheric pressure, they undergo a phase change in a range of temperatures around the ambient temperature. (Torraca)

A building with brick or stone walls take a long time to heat or cool during the day. This is because for years have employed high mass materials, which slow the flow of temperature, as a means to build passive, eco-friendly buildings. While these materials work well at regulating temperature fluctuations, they can be expensive, require additional structure and eat up building square footage. There is a same technology, but on a microscopic level, in the form of phase change materials. (Green Living , 2011)

The basic idea of passive buildings and thermal mass, is building materials with high mass (water, stone or concrete) collect and store heat throughout the day, and then slowly release it as the temperature drops. Ideally this design technique is used in climates who have extreme temperature fluctuations from day to night, or season to season. The thermal mass aids in a building's efficiency, reduces the need for heating and cooling equipment – and is done so without any moving parts. (Green Living ,2011)

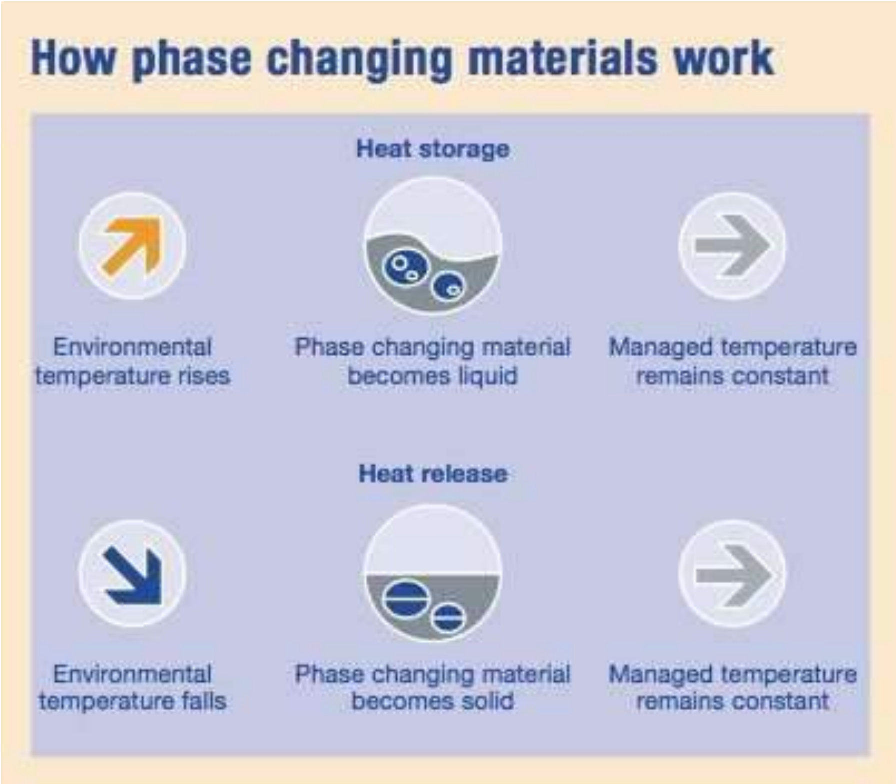


Fig.100 Work of PCM

PCM provide thermal mass, but on a much smaller scale. PCMs work by melting and solidifying at a specific temperature – heat is absorbed at the solid state, and when the material reaches a predetermined temperature, it changes to a liquid and releases the stored energy (heat). When the temperature falls below a predetermined degree, PCM re-solidifies and the process repeats. The most common PCMs come in the form of paraffin, fatty acids and salt hydrates, each with their own advantages and disadvantages. Most PCMs must be encapsulated to be stored and prevent evaporation and absorption. (Green Living , 2011)

There are several sectors in building industry that are looking to incorporate PCMs into their materials and products — some examples of this include drywall, windows, concrete and insulation. For example, when PCMs are embedded into drywall, an entire building is capable of storing energy, rather than just its exterior walls (where masonry is typically used). All walls that are sheathed with PCM embedded drywall are able to absorb and release heat around-the-clock to maintain a predetermined and desired temperature. By using drywall embedded with PCMs as thermal mass, instead of masonry or concrete, the building gains square footage that typically would've been lost to thick walls, and needs less structural support, which can get very expensive. (Green Living ,2012)

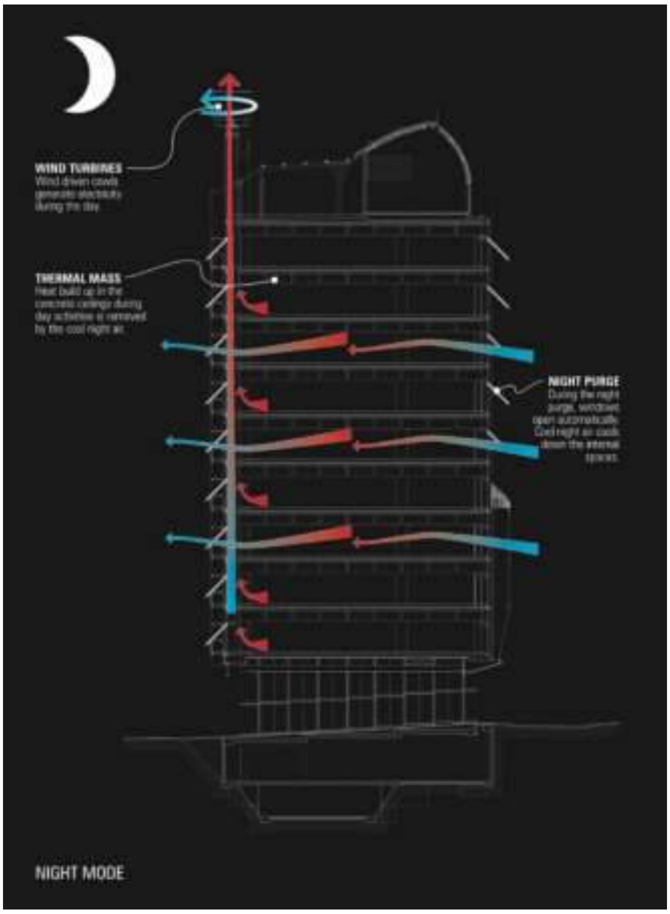


Fig. 101 CH2 Melbourne City Council House 2; DesignInc, Bioclimatic section night

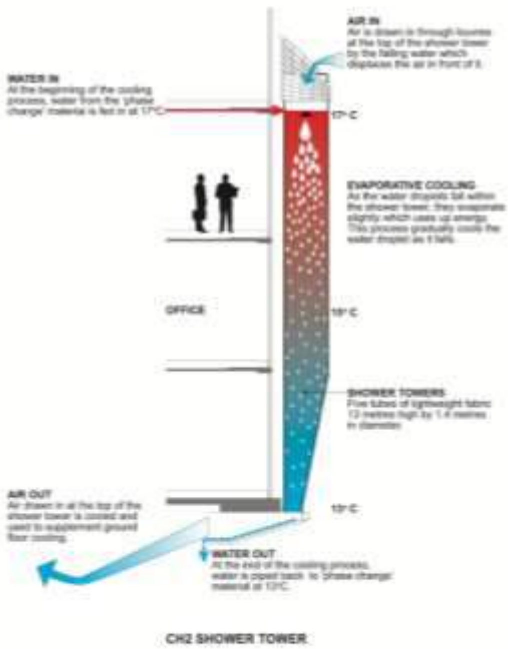


Fig. 102 CH2 Melbourne City Council House 2; DesignInc, Bioclimatic section detail

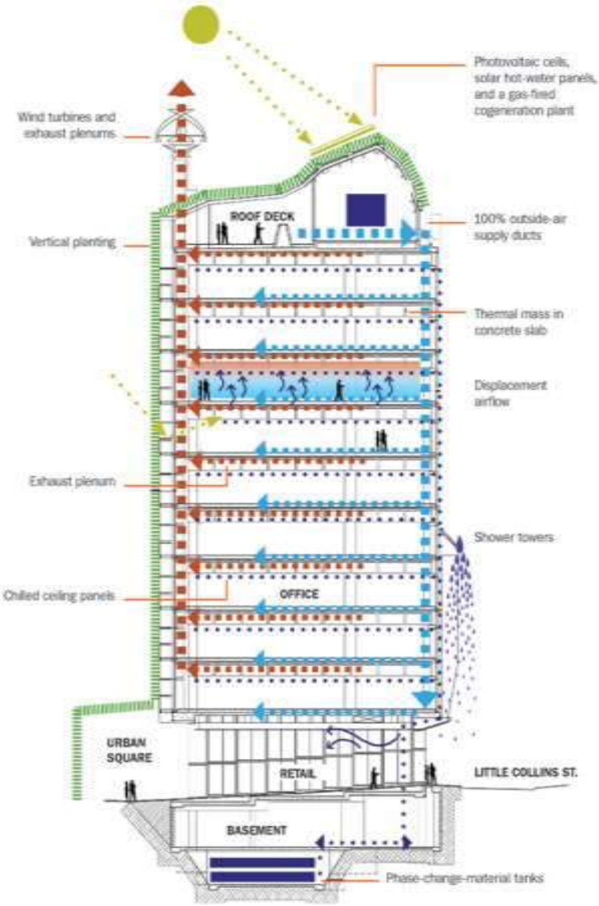


Fig. 103 CH2 Melbourne City Council House 2; DesignInc, Bioclimatic sectiont

Other current PCM applications include:

- BioPCM: BioPCM can be integrated into new construction or retrofitted into existing. It is a rolled mat that contains PCM; the mat is installed between insulation and drywall layers and can be located in walls and ceiling.
- GlassX: GlassX is an insulated glazing unit that can be used as full glass walls and windows. The unit has an outer pane of glass that reflects high-angle sun and allows low-angle sunlight to pass. Sunlight that is transmitted through this outer pane of glass passes through inner polycarbonate channels that are embedded with salt-hydrate PCMs. These PCMs store the heat from the sunlight, and release the heat to the interior of the building as the temperature cools.
- ThermalCORE: Made by National Gypsum/BASF Corporation, ThermalCORE is a drywall panel embedded with paraffin PCM. The microscopic paraffin capsules absorb and distribute heat as the wax melts and solidifies with temperature fluctuations. ThermalCORE is not currently commercially available for purchase and is still undergoing testing.(Zonbak)

Conclusion

The heat loss can be reduced in several ways. External Wall Insulation is a modern and advanced method that is estimated to save buildings losing. The insulation in the walls depends on the materials used for building. Building geometry is an important factor to consider from a design standpoint. Simplicity can save money, the more compact is the building the less heat he gives away. Insulation in walls, ceilings and floors helps to equalize cold and hot temperature. Heating requirement can be lowered by increasing thermal inertia in buildings and also the need for cooling. For that there are phase changing materials which collect and store heat throughout the day, and then slowly release it as the temperature drops by changing its material.

Providing Natural Ventilation

Physiological Cooling

Physiological Cooling and Human Thermal Comfort

Physiology in general is branch of biology that studies the functions and activities of living organisms and their parts, including all physical and chemical processes. When talking about physiological cooling, we are considering the physiology of humans specifically and how the human body temperature can be regulated with the help of different methods. ***The ultimate goal of physiological cooling is to achieve human thermal comfort*** and there are many factors determining this state (Reardon, Design for Climate 2013). These factors affecting thermal comfort of people are both physical (physiological) and psychological and they include but are not limited to:

- Temperature of surrounding atmosphere
- Humidity of the surrounding area
- Air movement in the room or other confined space (breezes, draughts)
- Exposure to radiant heat sources
- Exposure to cool surfaces to radiate, or conduct to, for cooling.

This chapter will investigate results of different factors affecting physiological cooling. It will deal with the problem of how these factors interact with human physiology and how we can manipulate them to benefit from it.

Humans are comfortable only within a very narrow range of conditions. On average, the human body temperature is considered to be about 37°C. Despite the fact that the body generates heat even while at rest, to achieve comfort, body must lose heat at the same rate it is produced and vice versa - gain heat at the same rate it is lost. The diagram below *(Fig104)*. (Graph by Steven Szokolay) shows the various ways by which human bodies achieve this equilibrium:

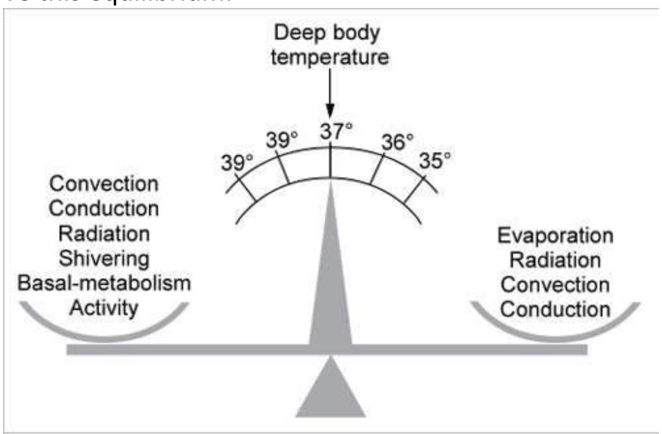


Fig. 104 Thermal equilibrium methods

Both human thermal comfort components - psychological and physiological are governed by the processes in the diagram above.

Physiological Cooling – Evaporation of Perspiration

Evaporation of perspiration (sweating) is considered the most effective physiological cooling process and it requires air movement and moderate to low humidity (less than 60%) in the room in order for it to succeed (Clarke 2013). Before moving on how air movement and humidity is required for this process, we will briefly discuss how evaporation of sweat cools the human body. When the ambient surrounding temperature is above the body temperature, then radiation, conduction and convection all transfer heat *into* the body rather than out. Since there must be a net outward heat transfer, the only mechanisms left under these conditions for the body are the perspiration (sweating) from the skin and the evaporative cooling from exhaled moisture. (Nave 2012) However, it is important to realize that In order for sweat to cool the human body temperature, it *must* evaporate from the surface. If it drips off or if it is wiped off with a towel, the body won't benefit from the cooling mechanism of evaporation. Beads of sweat on human skin are in liquid form, when its temperature rises, the molecules become more active and gain energy. When a molecule gains enough energy, it can break free from the bonds that hold the liquid together and transform into vapor. This is evaporation. As the molecules break liquid bonds and start to form gases, its energy (heat) is removed from the sweat that remains on the human body. This loss of energy (heat) cools the surface of the skin (Black 2013). Figure 2 below shows an example of evaporation of perspiration during a hot day (45°C).

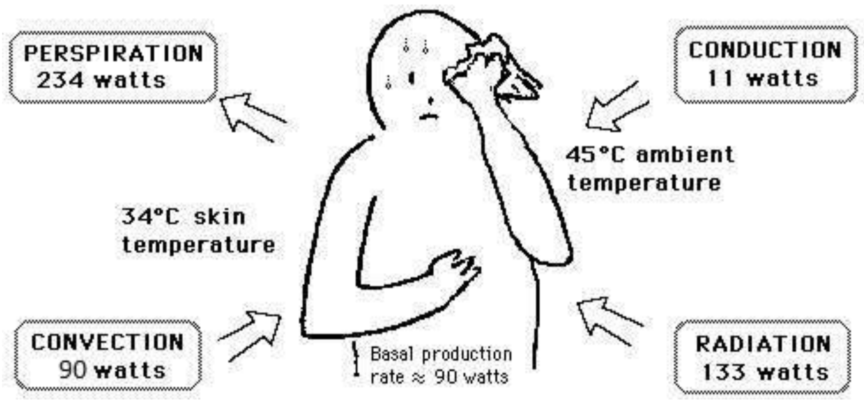


Fig. 105 Different processes during evaporation of perspiration

Even when one is unaware of perspiration, physiology texts quote an amount of about 600 grams per day of "insensate loss" of moisture from the skin. As part of the physiological regulation of body temperature, the skin will begin to sweat almost precisely at 37°C and the perspiration will increase rapidly with increasing skin temperature. Increased humidity levels decrease the body's ability to cool it through sweating. If the air already contains large amounts of water vapor, body sweat will not evaporate as readily, and the body temperature will not drop as quickly. While evaporative cooling is very effective in dry climates, there is a major drawback - the rapid loss of water and salts from the body through sweat. This can be fatal in less than a day if they are not replaced. (O'Neil 2009)

Experimenting With Various Cooling Methods

In the mid - 1980's, ASHRAE (global society advancing human well-being through sustainable technology for the built environment) began funding a series of field studies of thermal comfort in office buildings in four different climate zones. They were specifically designed to follow a standardized protocol developed as part of the first in the series, ASHRAE RP - 462 (Schiller, et al. 1988)

An interesting research has been carried out to study the effects of different cooling principles on human thermal comfort, physiological responses and productivity between males and females. The experiment involved a controlled climate chamber, a thermo-physiological test room *(Fig.106)* which was designed to study the effects of non-uniform environmental conditions on humans.

Fig. 106 Thermo-physiological test room

Without getting into much detail, the experiment involved 20 different people doing the same task in this controlled chamber in different air movement situations. In total, there were 6 types of conditions inside the room; each had a different cooling situation:

1. Passive cooling through mixing ventilations
2. Active cooling by convection through mixing
3. Active cooling through displacement ventilation (a room air distribution strategy where conditioned outdoor air is supplied at floor level and extracted above the occupied zone, usually at ceiling height. (Chen (1999).))
4. Active cooling by radiation through the ceiling and mixing ventilation
5. Active cooling by radiation through the floor and mixing ventilation
6. Active cooling through the floor and displacement

The results show that mainly the local thermal sensation votes of the body parts which are not covered by clothing influence the whole-body thermal sensation. *(Fig.116)* shows how 2 different subjects described their body sensations in 2 different conditions (Condition 1 and 4).

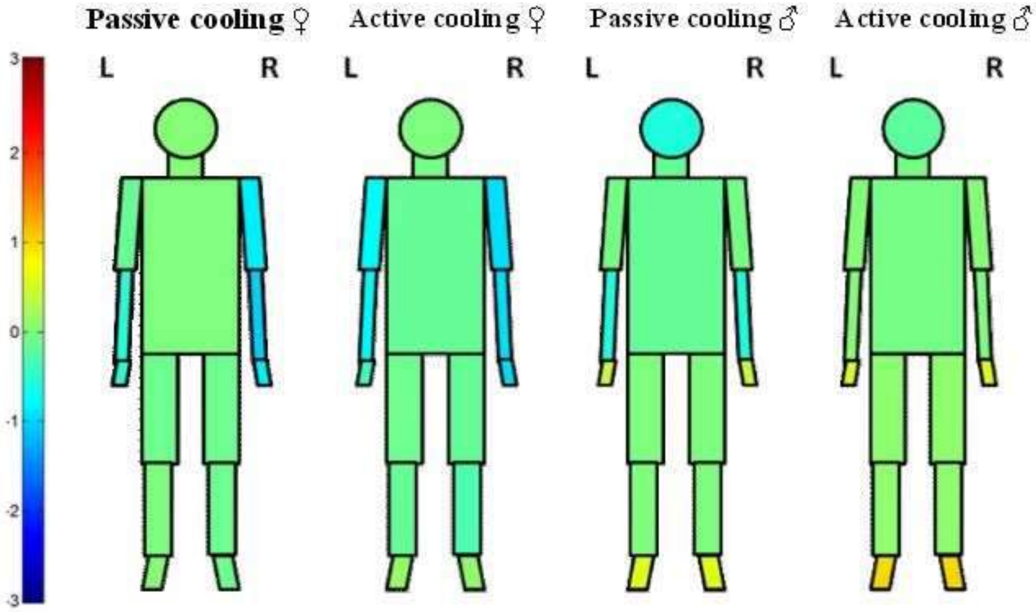


Fig. 107 Different body part responses

The numbers on left represent the 7-point ASHRAE thermal sensation scale (with 0 representing neutral) where positive numbers relate to dissatisfaction from heat while negative numbers relate to dissatisfaction from cold. (Brager 2005). Even though the experiment results were aimed to leave neutral sensation altogether, subjects did not feel completely comfortable in the given two situations. This kind of results seem to indicate that the boundary conditions of the ISO 7730 (type of analytical determination and interpretation of thermal comfort) are not applicable in situations where combined non-uniform environmental conditions occur, for example due to application of low energy systems (in thermodynamics, the energy of a system is the maximum useful work possible during a process that brings the system into equilibrium with a heat reservoir). It's also interesting to note that based on the presented preliminary results of this experiment, no preference for a specific type of cooling principle can be identified. (Schellen, et al. 2011)

Another study with the objective to investigate the mutual effect of local and overall thermal sensation (OTS) and comfort in displacement ventilation (DV) environment showed the results that in a space served by DV system, at OTS close to neutral, local thermal discomfort decreased with the increase of room air temperature. The OTS of occupants was mainly affected by local thermal sensation (LTS) at the arm, calf, foot, back and hand. Local thermal discomfort was affected by both LTS and OTS. As it would be expected, at overall cold thermal sensation, all body segments prefer slightly warm sensation. At overall slightly warm thermal sensation, all body segments prefer slightly cool sensation. (K.W.D. Cheong 2005)

Controlling Air Movement

Air movement is the most important element of passive cooling. It has the key role in evaporation of perspiration since it cools down the body surface of people by increasing evaporation rate. The natural ventilation like breeze of cool wind can be captured and used but in case of still climates, air conditioners and fans can be used as substitutes.

In all climates, air movement is useful for cooling people, but it may be less effective during periods of high humidity. For example, an air speed of 0.5m/s corresponds to an approximate 3°C drop in temperature of human body at a relative humidity of 50%. This is a one-off physiological cooling effect resulting from heat being drawn from the body to evaporate perspiration. Air movement exposes the skin to dryer air. Increased air speeds do not increase cooling at lower relative humidity but air speeds up to 1.0m/s can increase evaporative cooling in higher humidity. Air speeds above 1.0m/s usually cause discomfort. (Clarke 2013) Sensible air velocity however can be relied on to provide physiological cooling as mentioned before. The critical point is to ensure an air velocity at the body surface of the occupants.

Physiological cooling, the apparent cooling effect of air movement (dT) can be estimated as: $dT = 6 * v_e - 1.6 * {v_e}^2$Where the effective air velocity is $v_e = v - 0.2$ and v is air velocity (m/s) at the body surface and the expression is valid up to 2m/s. This formula estimates the effect of physiological cooling, which can be achieved with the wind effect, or by electric fans, most often by low-power ceiling fans. As tack-effect, relying on the rise of warm air cannot be relied on for this purpose. First, it would only occur when T i >T o , and that T i would be too high if T o is too high. Second, even if it works, it may generate a significant air exchange, but not a noticeable air velocity through the occupied space. Cross ventilation demands that there should be both an inlet and an outlet opening. The difference between positive pressure on the windward side and negative pressure on the leeward side provides the driving

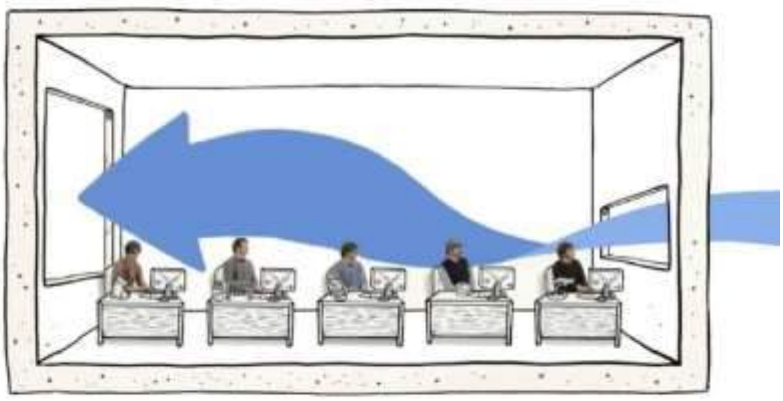


Fig. 108 Increased winds speed due to difference in size of outlet and inlet

force. Also, as visible on *(Fig. 108), pairing a large outlet with a small inlet increases incoming wind speed*. The inlet opening should face within 45◦ of the wind direction dominant during the most overheated periods. To produce the maximum total airflow through a space, both inlet and outlet openings should be as large as possible. The inlet opening will define the direction of the air stream entering. To get the maximum localized air velocity, the inlet opening should be much smaller than the outlet. Positioning the inlet opening, its accessories (e.g. louvres or other shading devices) as well as the aerodynamic effects outside (before the air enters) will determine the direction of the indoor air stream. (Szokolay 2004)

Control of Openings

Effect of sashes

Sashes, canopies, louvres and other elements controlling the openings influence the indoor air flow pattern. Sashes can divert the air flow upwards. Only a casement or reversible pivot sash will channel it downwards into the living zone

Fig. 109 How sashes effect ventilations

Effect of canopies

Canopies can eliminate the effect of pressure build-up above the window, thus the pressure below the window will direct the air flow upwards. A gap left between the building face and the canopy would ensure a downward pressure, thus a flow directed into the living zone

Fig.110 How canopies effect ventilations

Effect of louvres

Louvres and shading devices may also present a problem. The position of blades in a slightly upward position would still channel the flow into the living zone (up to 20° upwards from the horizontal)

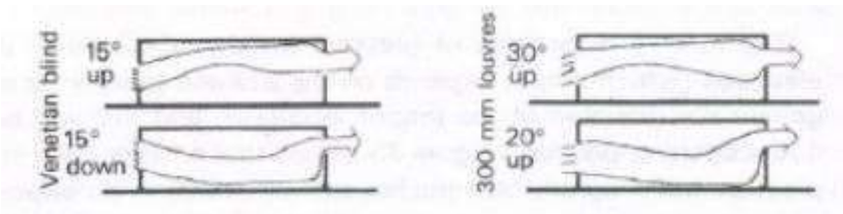


Fig. 111 How louvres effect ventilation

Air Quality

The following is an excerpt, introduction, to research by Spengler, J.D. and Chen, Q. about indoor air quality factors in design a healthy building.

"Current guidelines for green buildings are cursory and inadequate for specifying materials and designing ventilation systems to ensure a healthful indoor environment, i.e. a "healthy building," by design. Public perception, cultural preferences, litigation trends, current codes and regulations, rapid introduction of new building materials and commercial products, as well as the prevailing design-build practices, pose challenges to systems integration in the design, construction and operation phases of modern buildings. We are on the verge of a paradigm shift in ventilation design thinking. In the past, thermal properties of air within a zone determined heating, ventilating, and air- conditioning (HVAC) specifications. In the future, occupant-specific and highly responsive systems will become the norm. Natural ventilation, displacement ventilation, micro zoning with subfloor plenums, along with the use of point of source heat control and point of use sensors, will evolve to create a "smart" responsive ventilation-building dynamic system.

Advanced ventilation design tools such as the modeling of computational fluid dynamics (CFD) will be used routinely. CFD will be integrated into air quality and risk assessment models. Introduction At the beginning of the 21st century, "green building design" can be seen as being at the confluence of emerging societal interests, all seeking to use resources wisely in the design of health-promoting environments. The last decade saw the concept of the "global village" emerge through terms such as "sustainable development," "ecotourism," "ecotaxation," "socially responsible investment ," and "green architecture," among others.

Organizations representing private and public sector interests lay claim to these terms and attempt to establish the consensus to operational definitions, often suited to their perspective and constraints. Others are asking for a civil society that promotes social justice equality, and conservation through the ac tins of the public and private sectors. Green building concepts are simply a manifestation of these changes in our western society

Are “healthy buildings” a subset of “green buildings?” In the absence of widely accepted definition criteria, the answer is unclear at this time. The concept of a “healthy building” is still polemic, with no consistent guidelines. It is important to recognize that, although indoor air quality (IAQ) is an important determinant of healthy design, it is not the sole determinant, as occupants experience the full sensory world. Other parameters include lighting, acoustics, vibration, aesthetics, comfort and security, along with safety and ergonomic design factors. Drawing up on contemporary accounts of inner city asthma rates and cases of sick buildings, the building professions need more than cursory and inadequate guidance to incorporate indoor air quality considerations into their “healthy building” design. Problems with IAQ have traditionally been associated with older and poorly maintained construction (e.g., threats arising from the degradation of asbestos fireproofing or from Legionella contamination in cooling towers). Increasingly, however, building-related illnesses caused by poor air quality are being documented in newly constructed or recently renovated buildings. Poor IAQ is being blamed for a host of problems ranging from low worker productivity to increased cancer risk, and the resulting responses have produced action as severe as building demolition. Our building interiors once thought of as providing safe havens from the pernicious effects of outdoor air pollution and harsh climates may actually be more polluted than the surrounding ambient environment. As recently as 1994, the Building Owners and Managers Association (BOMA, Washington, DC) considered concerns with IAQ as “overblown” by activists who “continue to portray IAQ as an epidemic sweeping the nation.” OSHA proposed rule on non-industrial workplace air quality was published in the US Federal Register April 5, 1994. BOMA, in response, said that reports of IAQ problems were overplayed in the media, and that current concern for IAQ represents “mass hysteria...fueled by misinformation rather than conclusive scientific evidence.

Rather than being the product of a newly vocal minority, however, the increased publicity regarding IAQ at this time is representative of the convergence of many factors. These multifaceted attributes include a heightened public perception, litigation trends, and the current regulatory status, as well as long-term changes in construction systems, coupled with a shift in building occupancy and functional types. Rising expectations of occupants for healthy work environments are forcing building owners, operators, and managers to re consider the importance of IAQ. In a more recent survey conducted by the International Facility Managers Association, IAQ and thermal comfort were the top operational issues in all types of buildings. According to a recent telephone survey of building tenants commissioned by BOMA, “control and quality of air” was the fourth most important criteria for attracting and retaining tenants. The study also showed that quality heating, ventilating, and air-conditioning (HVAC) is extremely important for retaining tenants.

The problems with defining good IAQ are both multimodal and unprecedented, requiring a multidisciplinary approach for their investigation and resolution. This article 1 BOMA seemed to reflect concerns from building owners and construction professionals, who pointed to the need for source control by manufacturers. At the time BOMA urged federal efforts looking at causes, such as carpets, paints and coatings, and emissions from office equipment. Fundamentally their argument emphasized prevention at the manufacturing level, not management, once the sources were in the building. 3 begins with a description of several factors that lead to the wide acceptance that buildings and their IAQ can adversely impact occupants’ health. It continues with an offering of design guidance and evaluation tools to advance the state of practice. The article concludes with practical advice for evaluating the healthfulness of IAQ. “(Spengler 2000)

Example of building designed with physiological Cooling and air quality control

Dubai has experienced one of the greatest architectural booms in history. The most famous city of the United Arab Emirates is known for its unbearably hot climates, however, today's technological advancements made it possible for Dubai to be one of the best commercial cities in world. Because of the extreme climate, all the buildings require cooling so that they become habitable and bearable by humans.

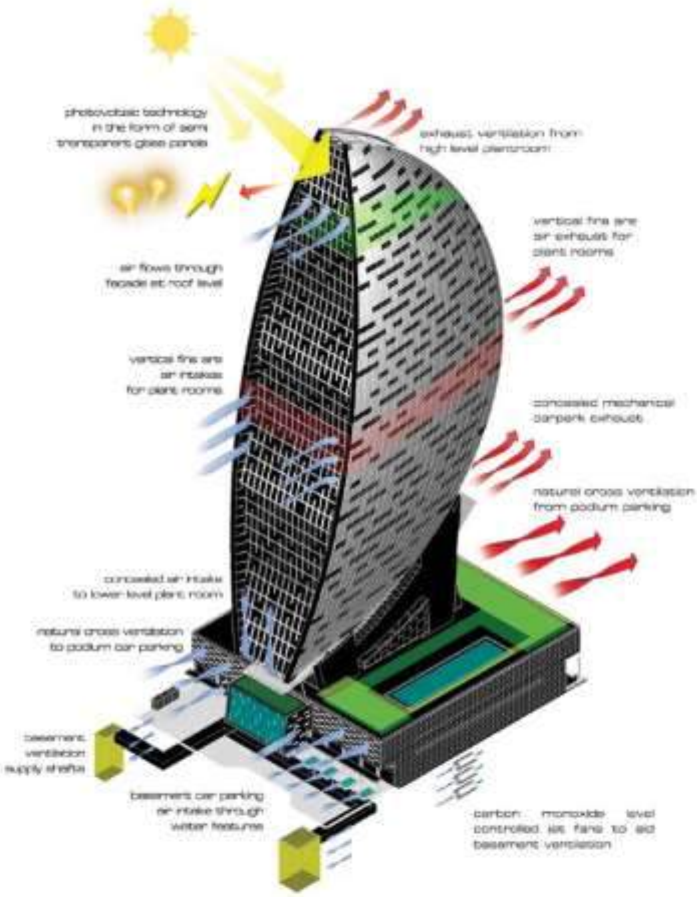


Fig. 112 Sheth Tower

One of the many examples of a successful green building is Sheth Tower, on Iris Bay *(Fig.112)*. It was an early opportunity for Atkins (a British multinational engineering, design, planning, project management and consulting services company) to explore the challenges of sustainable design in a hot climate and incorporates both passive and active environmental features. The firm was commissioned as lead consultants for architecture, structural, mechanical and electrical engineering design, and project management for the entire development. The tower comprises two identical double curved pixelated shells which are rotated and cantilevered over a four-story podium, underneath which are three levels of basement designed to facilitate underground parking for 920 cars. The distinctive ovoid shape creates areas of negative pressure that draws air through the building and reduces the dependence upon mechanical ventilation for the underground car park in particular. The rear elevation is a continuous vertical curve punctuated by balconies while the front elevation is made up of seven zones of rotated glass. This includes naturally ventilated spaces and integrated solar energy and shading films in the glass façade. (Welch 2014)

Conclusion

In general, humans strive to have comfortable habitats. The human physiological comfort is one of the most important factors to consider as an architect, since the designed buildings are firstly made for humans to occupy. Lots of factors are included in determination of the physiological comfort, an important factor is the human thermal factor. A person should physically be calm in the designed building and temperature plays a big role in this. Physiological cooling considers this important human comfort factor and tries offers different solutions to control and affect the human temperature inside the designated building. The methods include controlling and integrating natural ventilation, planning carefully the air conditioning and taking into consideration the climate of the surroundings.

Another very important factor, and compared to thermal comfort, more vital, is healthiness of the surroundings where humans spend time. In this case I am referring to the quality of air in the buildings. Since late 20th century, this has been looked at many times and throughout the years, along with advancement of technology, possibilities of controlling the air quality have greatly changed. Today it's even possible to have healthy air in the middle of polluted city, if desired. The advanced technology offers tools like modeling of computational fluid dynamics which will be integrated into air quality and risk assessment models.

Overall, physiological cooling methods and air filtering are more varied and manageable than they have ever been, thanks to the advancement in technologies. For an architect, it is vital to think about how the architectural design will use different methods to achieve human thermal comfort and healthy air quality indoors.

Air Cooling

Based on various information starting Wikipedia and ending David's Etheridge "Natural Ventilation of Buildings", air cooling is a very important aspect in ventilation. Air cooling can be produced by a numerous amount of technologies, but in this report the main goal is to show the less costing and energy draining methods of air cooling through simple steps from explaining: what is air cooling, what is natural ventilation, why it's important to ventilate a buildings, what are the types of air cooling and etc.

It's a process of lowering air temperature by scattering heat. It provides increased air flow and reduced temperature. Air cooling should be taken seriously like a really important aspect of living houses. Along with this process, when it is necessary or appropriate, the air is filtered, heated or cooled and moistened or drained. Such a change being enclosed air space provides:

Addition of O2 in the air
Reducing the concentration of CO2
Excess water vapour eliminated
Removal of air pollutants.

Fig. 113 Air Space Providing Table

Ventilation species of the enclosed space:

premises and building ventilation
vehicles (cars, aircraft, etc.) booths and interior ventilation
Clothing (area under clothing, footwear, etc.). Ventilation
pulmonary ventilation (so-called external respiration)
smoke ventilation (also called - fire overpressure system)

Fig. 114 Enclosed Space Without Ventilation Spieces Table

There are also several reasons why it is necessary to ventilate certain premises:

Factories that produced or used in an explosive and flammable substances (e.g., Paints, varnishes, etc.). Unventilated premises would face a real risk of fire or explosion.

In wet areas (e.g., Basins) ventilation is necessary to remove excess moisture, because otherwise there is mould, moisture from decaying different structures and properties of thermal insulation material is degraded.

Recommended ventilation conditions

Housing that the air is dry and clean, fresh stream must flow from the vent in unventilated spaces. If the room is sealed and the air enters through the windows, it is desirable that the air in the room change from 0.5 to 0.8 times per hour.

Natural ventilation

Is the process of supplying and removing air through an indoor space without using mechanical systems? It refers to the flow of external air to an indoor space as a result of pressure or temperature differences. There are two types of natural ventilation occurring in buildings: *wind driven ventilation* and *buoyancy-driven ventilation*. While wind is the main mechanism of wind driven ventilation, buoyancy-driven ventilation occurs as a result of the directional buoyancy force that results from temperature differences between the interior and exterior.

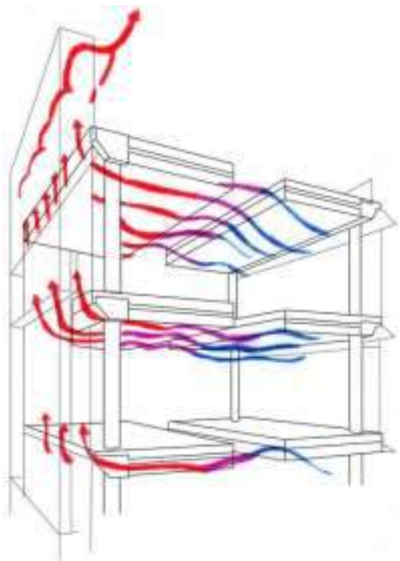


Fig. 115 Section ofhow natural ventilation works through the gaps of the building flooring

Advantages and Disadvantages of Natural Ventilation

It is difficult to make definitive statements about the advantages and disadvantages of natural ventilation compared to mechanical systems and air conditioning, partly because they depend to some extent on the intended use of the building and the climate in which it lies.

Perhaps the main advantage claimed for natural ventilation is that it contributes to a sustainable building environment. Bearing in mind the thousands of years that natural ventilation has existed, this claim is difficult to dispute. One contributory factor here is that natural ventilation requires no electrical energy for fans, which can constitute 25% of the electrical energy consumption in a mechanically ventilated building. To some extent, a balanced mechanical system can compensate for this by making use of heat recovery, but to be successful a very tight envelope is required.

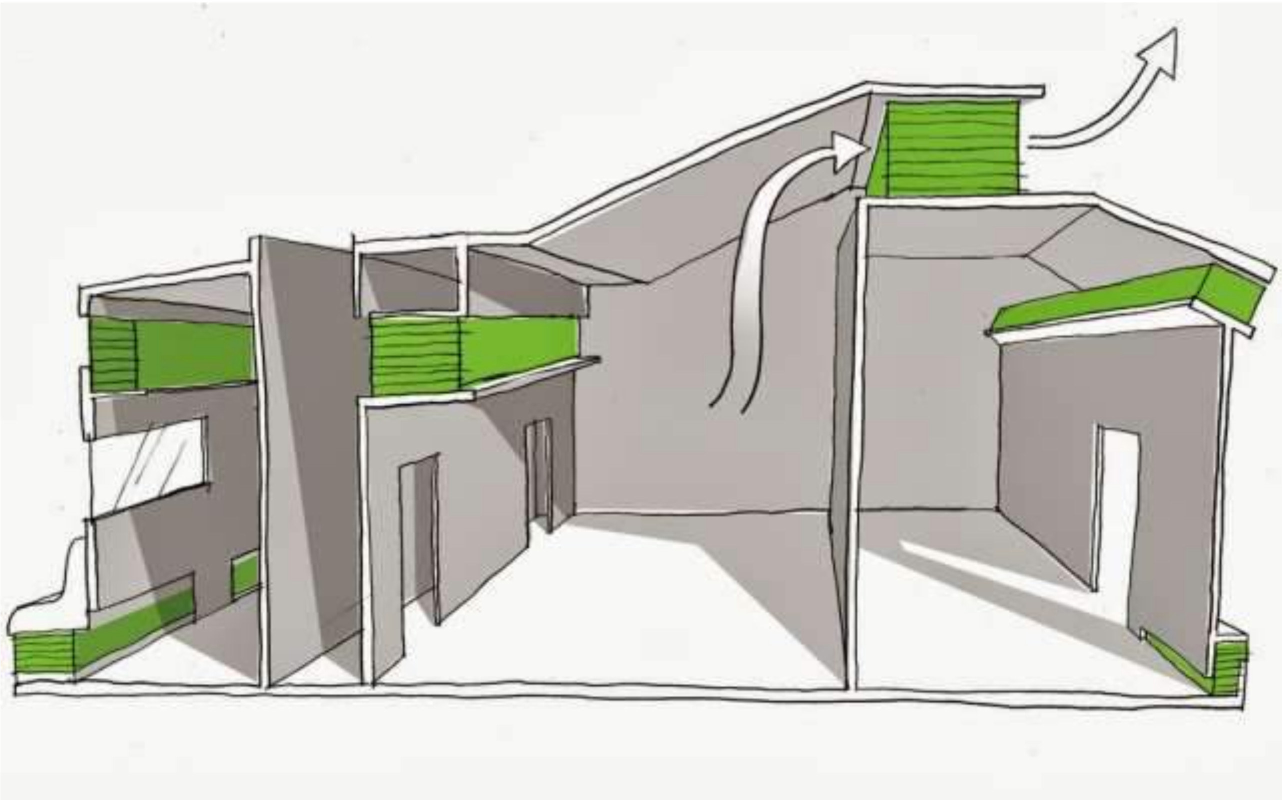


Fig. 116 Section of Ventilation

There is also evidence that occupants of buildings prefer to have control over their environment and prefer not to be completely isolated from the external environment.

Natural ventilation can satisfy both these needs, whereas a conventional air-conditioning system does not.

A disadvantage of natural ventilation is that it is limited in the extent to which it can provide cooling in hot climates and particularly ones that are also humid. For natural ventilation to be acceptable in some climates, it is necessary to combine it with some form of sustainable (low-energy) cooling system.

From the commercial viewpoint, it is often claimed that natural ventilation systems offer reduced capital cost and lower operating costs (energy, maintenance) than mechanical systems.

For a simple building like a house, this seems reasonable, although energy reductions rely on ventilation losses being kept lower than those achievable with a mechanical system. With on-domestic buildings, other commercial issues may override the savings associated with natural ventilation e.g. maximising the use of floor area; integration of the ventilation system with heating and cooling; close control of conditions for equipment and processes. Natural ventilation does not require space for plant rooms or networks of ducts, but space is often required for stacks (chimneys, atria). Particular disadvantage is that errors in the design of a natural ventilation system may be more difficult to correct. Mixed-mode systems offer away round this problem.

Fig. 117 House of Isaac Newton

The role of natural ventilation in providing a comfortable and healthy environment forms the basis for the design criteria for most domestic and non-domestic buildings. The common requirement for a minimum fresh air flow rate of about 10 litres s–1 per person is based on the removal of body odours and this is usually sufficient to cope with other contaminants generated within buildings. In a free-running building during the cooling season the flow rates are likely to be much larger. There are, however, specific safety issues in which ventilation plays a role. Accidental release of flammable gas in buildings is an acute example. Such incidents are rare and it would be unrealistic to base the design of a ventilation system on their occurrence. There are other ways to reduce the risk of explosion e.g. colourisation of the gas and gas detectors.

Low-energy Cooling Systems

Conventional free-standing or wall-mounted air conditioning units can of course be installed in naturally ventilated buildings. However, since one aim of natural ventilation is to reduce energy consumption, it is clearly desirable that any cooling system should be generally recognised as being of a similar nature. The definition of what constitutes a low-energy system is not precise, particularly when it makes use of renewable energy. So the following selection of systems is not exhaustive. It has been made on the basis that the system is associated with natural ventilation in some way, either in the sense that it forms part of the ventilation strategy or is used to enhance night cooling. Passive systems are taken to be ones that require no artificial source of energy (electricity), whereas active systems require some input. The performance of an active system is usually measured in terms of its coefficient of performance (COP), which is the ratio of the rate of cooling of the system (kW) to the electrical input (kW).

- **Passive**

Direct ventilation cooling and night cooling are passive techniques. The temperature reduction provided by night cooling can be quite small. However, there are ways that it can be enhanced, yet still remain purely passive. One way is the use of additional mass, such as concrete beams in.

The aim is to maximise the thermal contact with the internal air, so the material needs to be fully exposed. A more recent development is the use of wallboard containing a phase change material (PCM). The latent heat storage capacity of the material is a way of increasing the thermal mass of the envelope with a small increase in the actual mass.

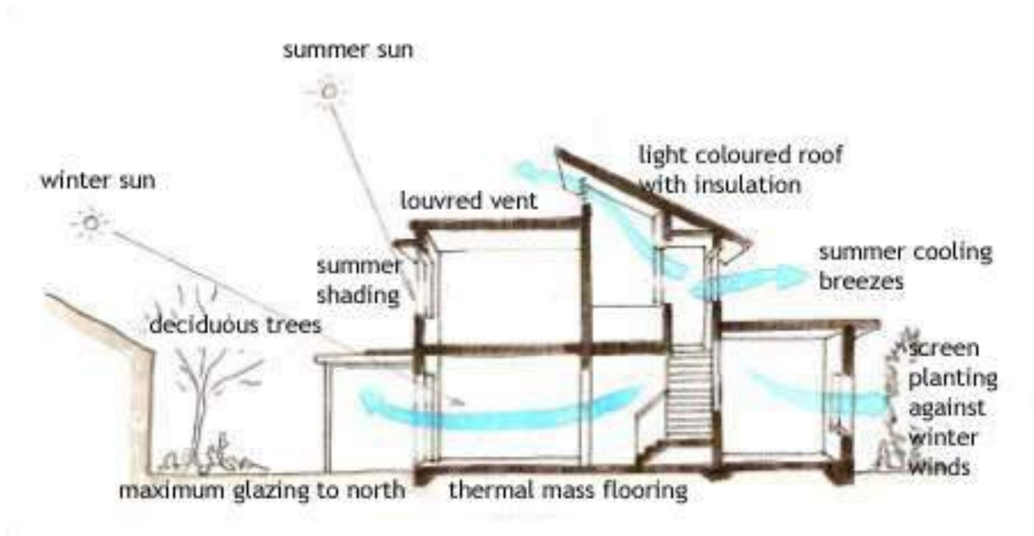


Fig. 118 Section of Natural Ventilation

- **Active**

Three active systems are considered: passive downdraught evaporative cooling (PDEC), passive downdraught cooling (PDC) and active PCM. The first two systems are described as passive in their title. However, they have high COP values, particularly the PDEC system. As its name implies, the PDEC system cools the air by the evaporation of water. High rates of evaporation are achieved by injecting water into the space in the form of a spray. The latent heat of evaporation leads to cooling of the surrounding air, which increases its density (the increase in humidity leads to a smaller reduction in density). By injecting the water at high level, top down ventilation is promoted so that the cooled air flows into the occupied spaces. The system is most suited to hot and dry climates and this limits the extent of its application.

The PDC system also cools the air at high level to promote top-down ventilation but this is done by means of a cooling coil containing chilled water (or a similar device). The PDC system is inherently less passive than PDEC, but it is not limited to dry climates.

An active PCM system is one where heat transfer from the air to the PCM and vice versa is enhanced by forced convection. Typically, the PCM material is placed in a container and during the day the warm room air is passed over the PCM by means of a fan. During the night the heat absorbed by the PCM Is removed by passing cool air from the outside over it. The increased heat transfer rates are sufficient to allow the internal air temperature to be controlled in much the same way as a conventional cooling system (subject to the storage limitation imposed by the mass of the PCM). This model includes simulation of the control algorithm for the system. It can be seen that the system is capable of controlling the air temperature to a set value (until such time as the latent thermal storage is exhausted). Since the internal temperature is less than the external temperature, the daytime ventilation rate is kept at
a low value.

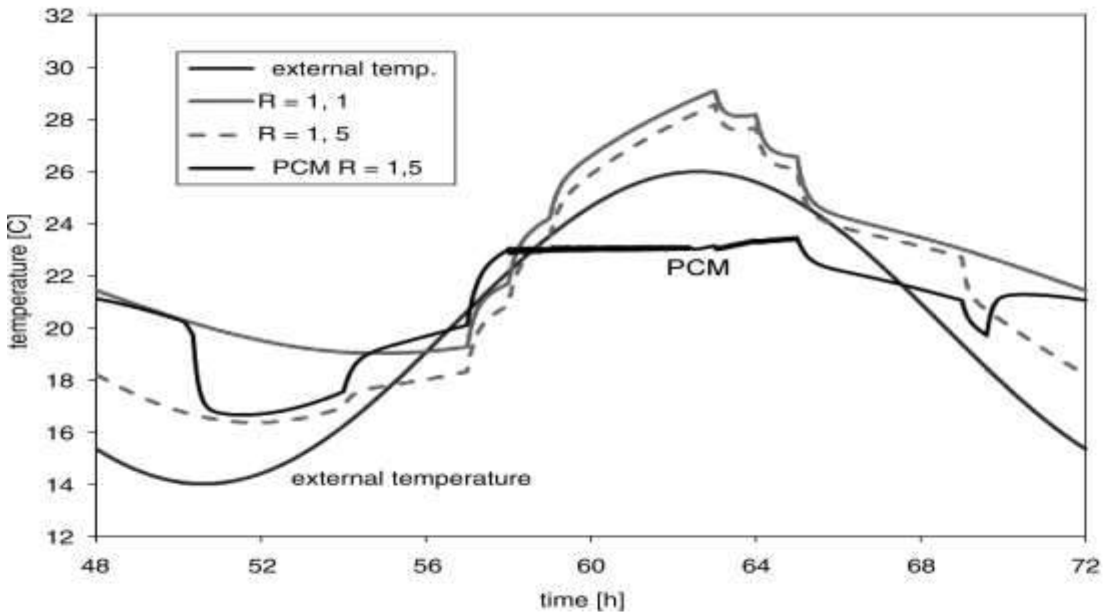


Fig. 119 Graph of Controlled Air Temperature Differences

Evaporative cooling

Evaporative cooling is the oldest form of air conditioning ever used. The ancient Greeks used to fill terracotta pots full of water and leave them by doors and windows to benefit from evaporative cooling. The Arabs hung wet blankets over doors and windows to achieve the same effect

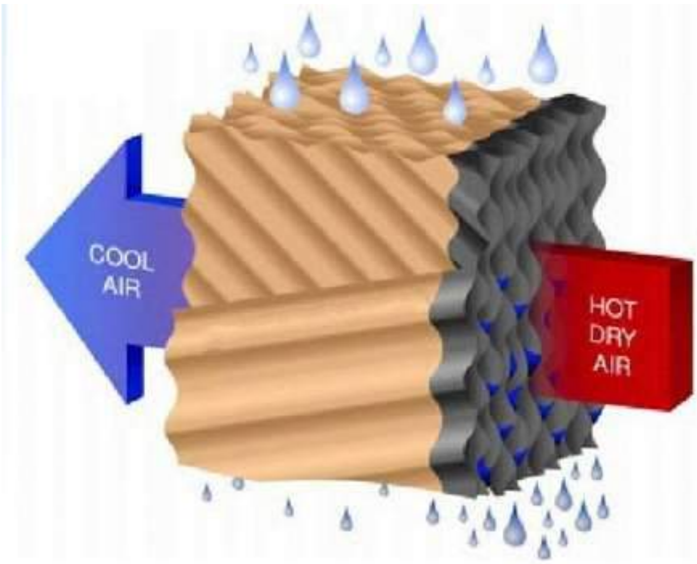


Fig. 120 Evaporative Cooling Explanation

It's a device that cools air through the evaporation of water. The difference between evaporative cooling and air cooling is that evaporative cooling system uses vapour-compression or absorption refrigeration cycles. It works by using heat of vaporization.

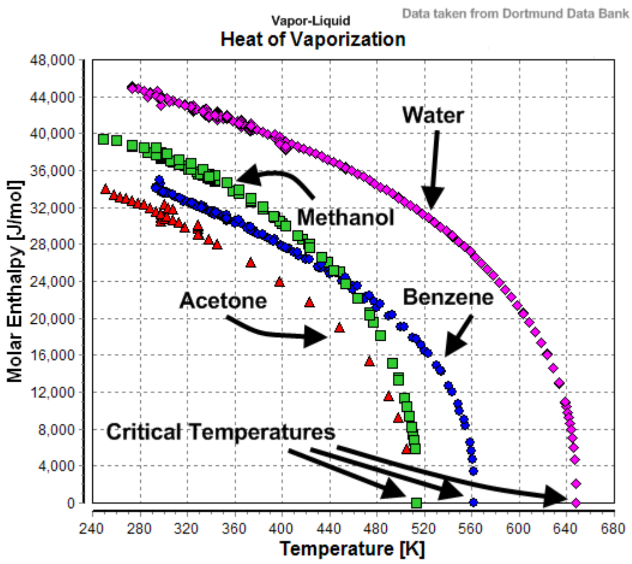


Fig. 121 Graph of Heat of Vaporization

Dry air temperature can be dropped significantly through the phase transition of liquid water to water vapour (evaporation), which is a part of natural ventilation because it uses less energy than refrigeration. In extremely dry climates, evaporative cooling has its strengths of condition the air with more moisture for the comfort of people living in the building.

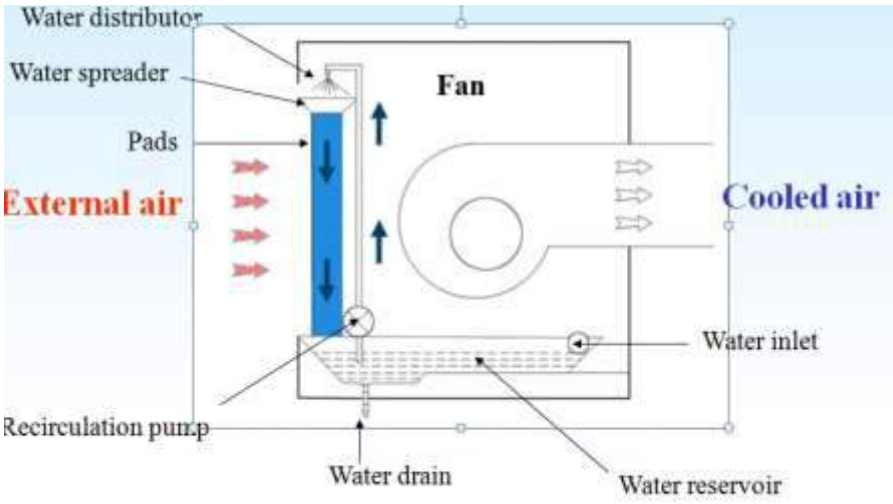


Fig. 122 Air Coonditioning Principle

1. Ground cover
2. Water sprinkler
3. Insulated roof
4. Shading trees
5. Water trough

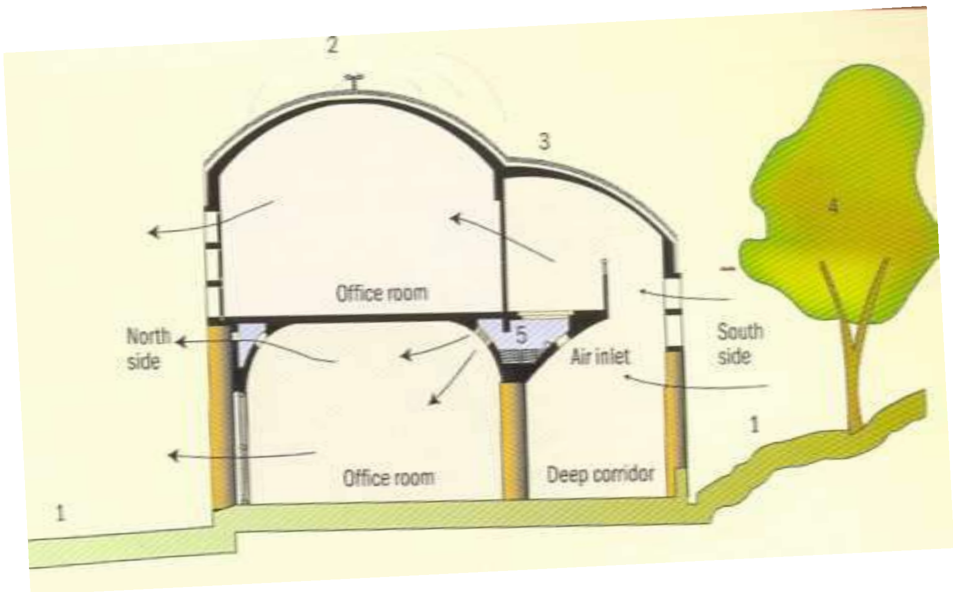
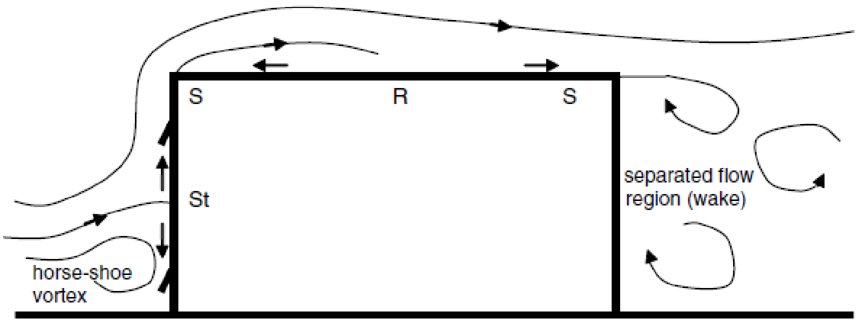


Fig. 123 Section of Natural Ventilation



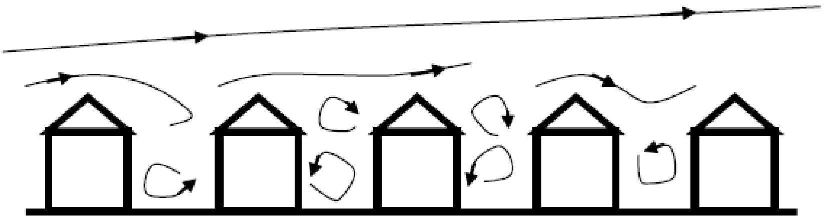


Fig. 124 Explanation of Air Flows

The relatively low thermal capacity of air means that quite small internal heat gains generate uncomfortable temperatures. Natural ventilation alone can remove heat directly and in this sense (prevention of overheating) it provides cooling. This process requires that the internal temperature be greater than the external temperature and is not cooling in the strict meaning of the term. However, evaporative cooling of occupants by high air speeds can be significant. Removal of internal heat gains is limited by several factors e.g.

The acceptable internal temperature and the ventilation rate that can be achieved. This means that minimising the internal heat gains during the summer is usually an important part of the building design. In an office building, a large part of the internal gain will come from occupants, and this cannot be reduced. Reducing the heat gains from lighting, solar radiation and equipment is therefore an important design issue. As a rough guide, in a Northern European climate, the internal heat gains should be less than 20 to 40Wper m2 of floor area. Larger values probably require some form of purpose-designed cooling (passive or active), as discussed in Section

Circulating air through underground ducts

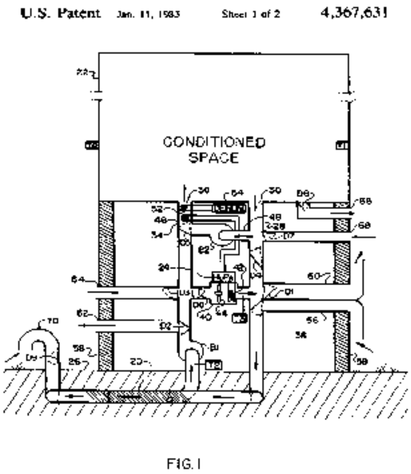


Fig. 125 **Section of Underground Ducts**

An underground duct is connected to other duct and controls associated with a building for automatically selectively passing outdoor air through the underground duct to the normally outdoor coils of a heat pump, recirculating air through the underground.

Alternatively, air from the underground duct or from outdoors is selectively passed directly into the building for optimum cooling thereof while a dehumidifier is used to remove latent heat from the air; and other heat sources may be used with direct recirculation of air through the building and addition of a portion of tempered air from the underground duct for slightly pressurizing the building interior with heated air.

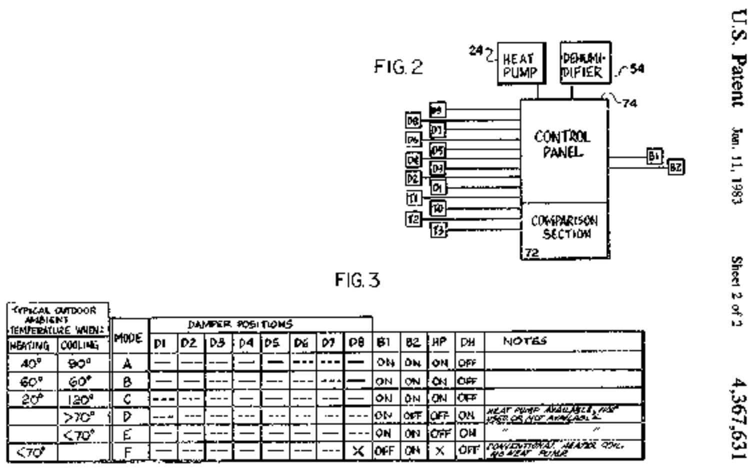


Fig. 126 **Graph and Scheme of Underground Ducts**

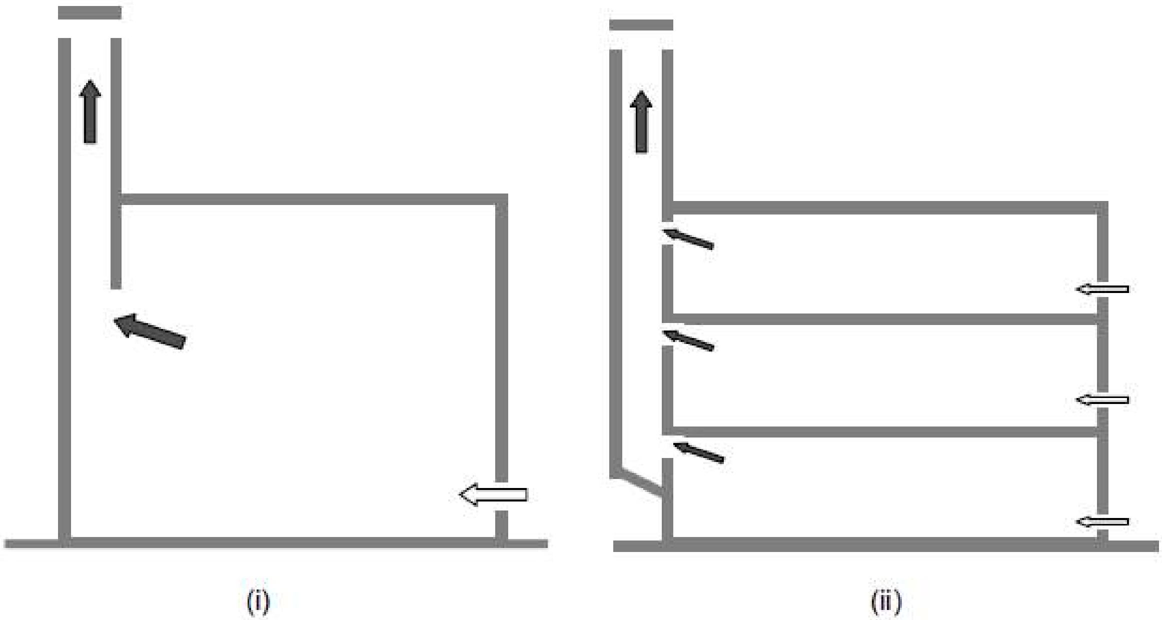


Fig. 127 Upward flow induced by a chimney to provide cross-flow ventilation: (i) single-cell building; (ii) four-cell building (includes chimney as a cell) (Etheridge, Natural Ventilation of Buildings 2010)

(Fig. 126-127) illustrate what might be termed the classic natural ventilation strategy. Some form of stack with a high-level outlet is used to generate cross-flow ventilation through the occupied spaces. Provided the wind pressure coefficient at the stack outlet remains negative compared with the coefficients at the inlet openings and provided the internal temperatures are greater than the external temperature, the upward flow pattern should be reliably maintained.

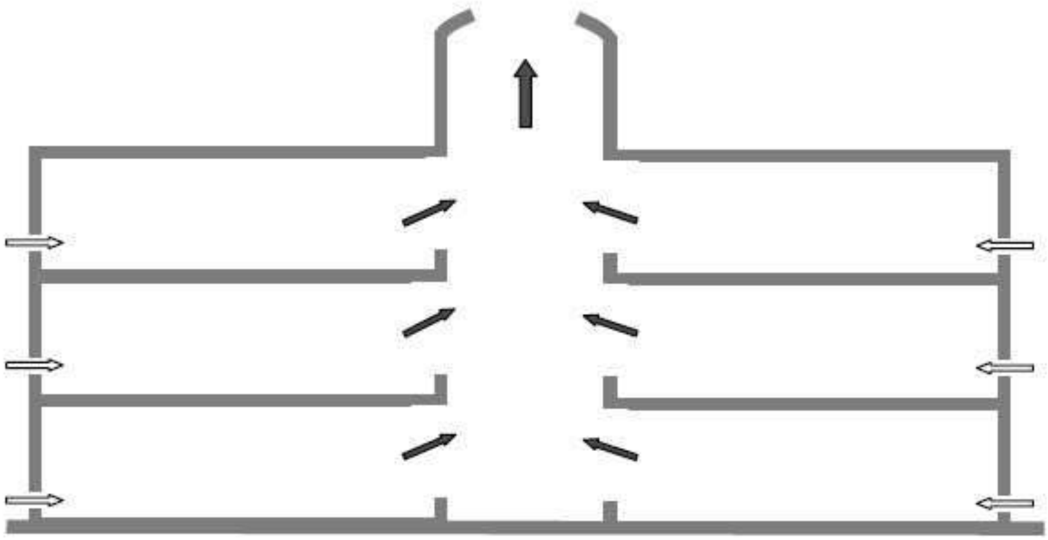


Fig. 128 Upward flow induced by an atrium to provide cross-flow ventilation, single-cell building *(Etheridge, Natural Ventilation of Buildings 2010)*

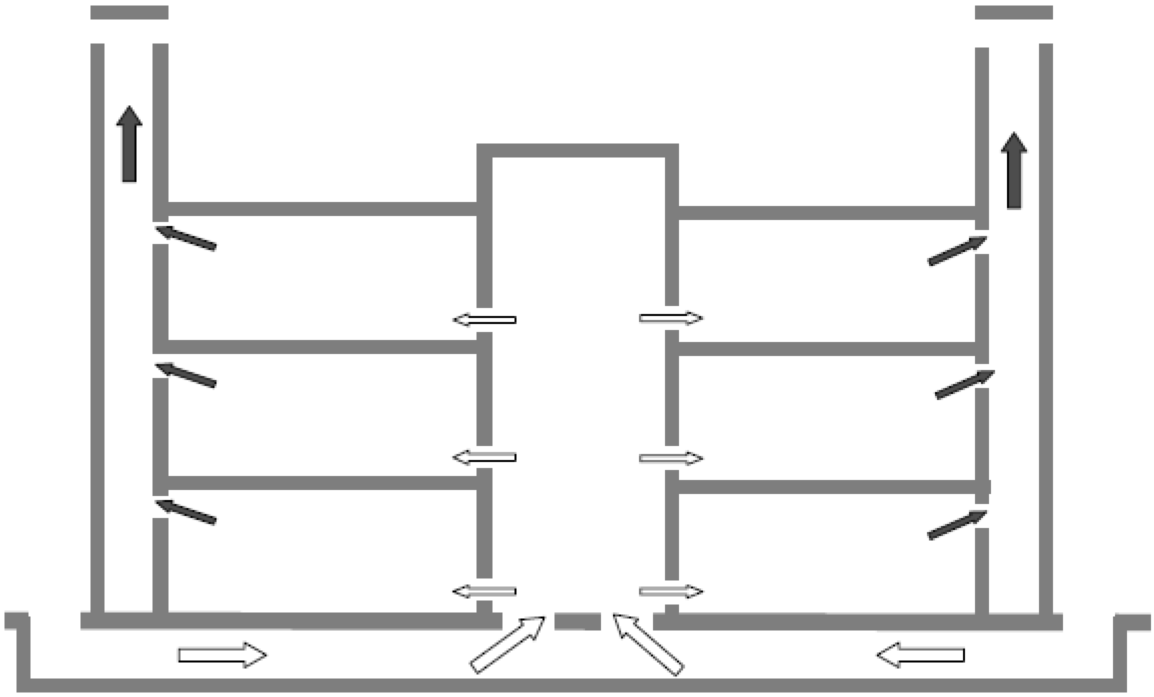


Fig. 129 Upward flow induced by chimneys to provide cross-flow ventilation. Provides internal fresh-air entry *(Etheridge, Natural Ventilation of Buildings 2010)*

Underground ducts can provide cooling and heating of the inlet air, by virtue of heat transfer between the air and the surrounding ground material, which remains at a moderate temperature throughout the year. When driven by mechanical fans, the COP can be high. Underground ducts raise questions about air quality, but this does not seem to be a barrier to their use. In passing, it can be noted that the age of air entry is increased byVd=Qd; where VdandQd denote the volume and the volume flow rate of the duct, because that is the average age at the outlet of the duct is much less than the volume of the building, the increase in age will be small.

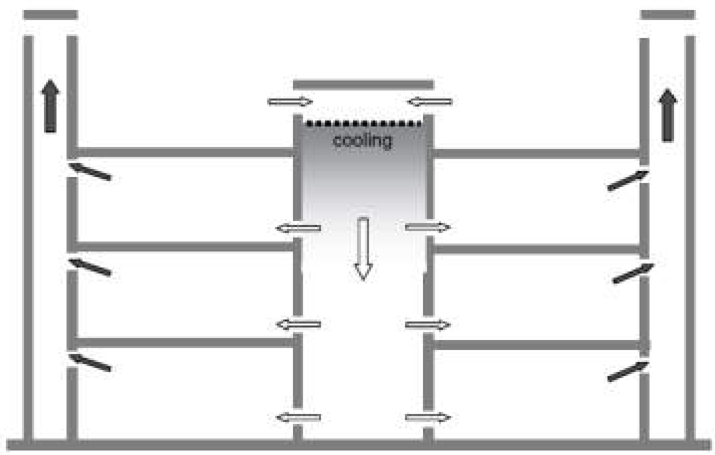


Fig. 130 **Top-down ventilation induced by cooling of air at top of light well (and possibly heating of chimneys)** *(Etheridge, Natural Ventilation of Buildings 2010)*

These types of air circulation have a natural impact on architectural design. The architect finishes his main concept on the building and then researches what kind types he should choose for his project. I chose the *(Fig. 129)* Upward flow induced by chimneys to provide cross-flow ventilation, because it seem to me the most accurate choice and it provides internal fresh-air entry. This is how it looks on my project:

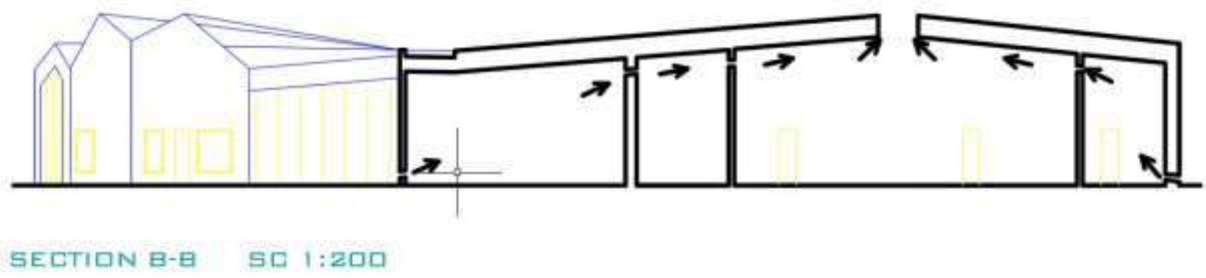


Fig. 131 Section of Administrational building for Recreational Complex in Nature (by Alanas Segalis 2014 y.)

Under Floor Ventilation Using Elevated Flooring

The increased use of suspended floors, which are replacing the traditional methods of using concrete raft foundations in buildings has meant that the requirement to provide sufficient ventilation to the voids below floor level has also become paramount. Building Regulations and NHBC guidelines state that a gap between the ground and the underside of the floor should be provided to prevent the build-up of condensation and contaminated air, and that this void should be adequately ventilated. Manthorpe's range of through wall and under floor ventilators diffuse potentially dangerous gases, such as methane, which can seep from the ground in the space beneath timber and concrete suspended floors. They can be used individually or as a combined system to provide a complete ventilation package. Sub floor and cavity wall ventilation from Manthorpe Building Regulations Part C - 'Site preparation and resistance to contaminants and moisture along with the NHBC Standards 5.2 - 'Suspended ground floors' outline the requirements for the type and frequency of ventilation openings to an under floor void. Ventilators should incorporate suitable grilles which prevent the entry of vermin to the sub-floor but do not resist the air flow unduly. If floor levels need to be nearer to the ground to provide level access, then sub-floor ventilation can be provided through offset (periscope) ventilators .Two opposing external walls should have ventilation opening s placed so that the ventilating air will have a free path between opposite sides. Where this is not possible, effective cross ventilation from opposite sides should be provided by a combination of openings and air ducts. As a rule of thumb, Manthorpe recommend following the NHBC guide that ventilators should be spaced at not more than 2mcentres and within 450mm of each end of the opposing walls.

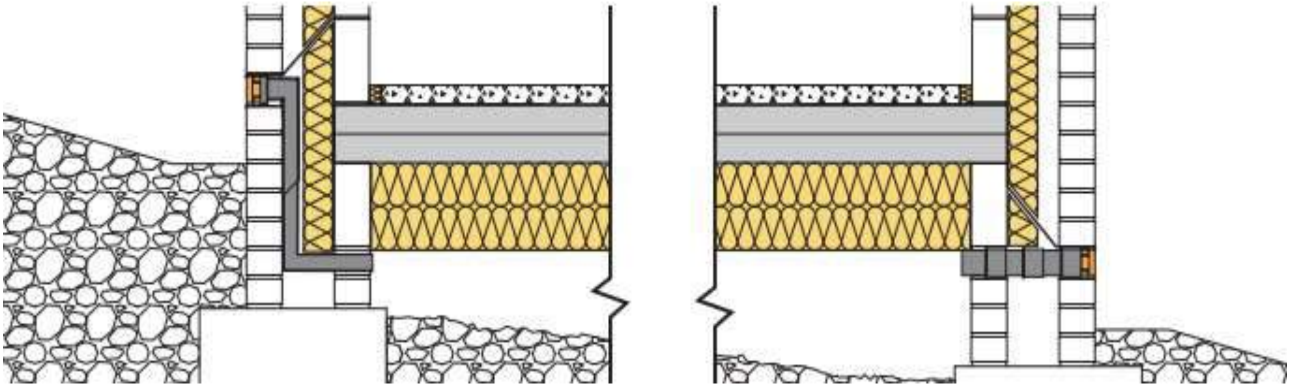


Fig. 132 This section shows how the under floor ventilation is used and how it works. *(Products 2013)*

Conclusions

Air cooling is important aspect for buildings and for people living in the buildings. Regarding the advantages and disadvantages of natural ventilation, the less energy costing air cooling is what it should be picked. It's natural, sustainable, and environment-friendly. Natural ventilation can satisfy these needs, whereas a conventional air-conditioning system does not.

However, a disadvantage of natural ventilation is that it is limited in the extent to which it can provide cooling in hot climates and particularly ones that are also humid. For natural ventilation to be acceptable in some climates, it is necessary to combine it with some form of sustainable (low-energy) cooling system. That's where the evaporative cooling and underground duct system comes in and shows what are the best solutions for air cooling. It's semi mechanical and semi natural, low-energy cooling system. This provides less power consumption, environment-friendly work and less cost.

Those are the main arguments for what is air cooling, what kind of air cooling it should be and why it's important.

Envelope Cooling

There are many ways how a building can be protected from overheating. One of the most used ways is ventilation. There are multi ways of ventilating a building, for instance, natural or mechanical, cross or stock ventilation. These methods provide different results, which concern energy consumption, harm to the environment, maintenance costs and many others. Three ventilation types are going to be introduced: buoyancy driven ventilation, night ventilation (thermal mass), cross ventilation. Each type is going to be explained to get an understanding how it works. Advantages and disadvantages are going to be presented accordingly to know how well each type of ventilation can be used to different kind of plots.

Buoyancy driven ventilation

Buoyant (rising) type ventilation is commonly used for high rise buildings. It is considered to be natural ventilation type, because no mechanical interference is required for the building to ventilate on its own. This type of ventilation arises due to different air density inside and outside of the building. Simply put, when different masses of air adjoin, the one which is warmer will be less dense therefore it will be more buoyant and it will rise above the cold air *(Fig. 133)*. This process creates and upward stream of air. In order for a building to be ventilated via buoyant driven ventilation, the outside and inside temperatures have to be different from one another so that warmer indoor air would rise and escape the building via higher apertures and cold air would enter the interior thus creating a flow of air *(Fig. 134)* Buoyancy driven ventilation increases with greater temperature difference. To prevent displacement ventilation the height difference between the higher and lower apertures has to be at its maximum.

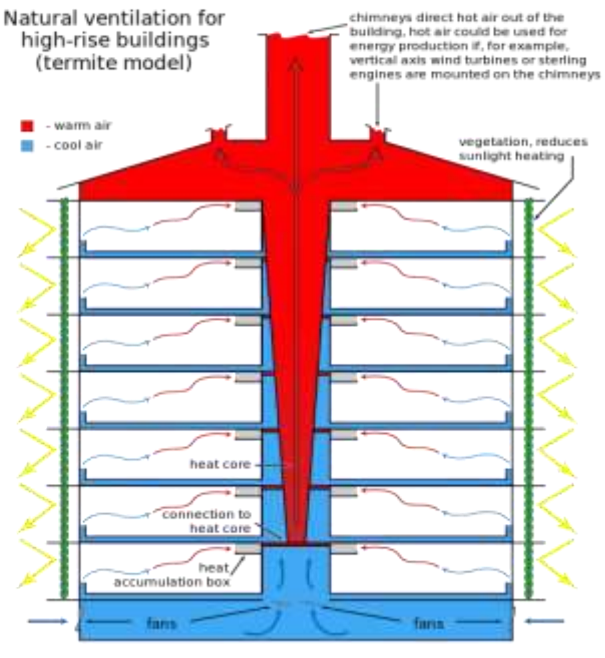


Fig. 133 Scheme of hot air collection and transfer

Advantages of buoyant ventilation:

- Does not rely on wind: can take place on still days
- Stable air flow (in comparison to wind)
- Greater control in choosing areas of air intake
- Sustainable method

As we can see from the pictures (*Fig. 134; 135)* the advantages of buoyant ventilation can be clearly seen from the stability of the system. This system is stable because there are basically no parts that are need to be mechanized therefore the energy consumption of his type of system is significantly less. The system is self-sustainable because air is the main driving force also because of this, the system does not require wind to be present or other air conditioning units that would intake air into the building.

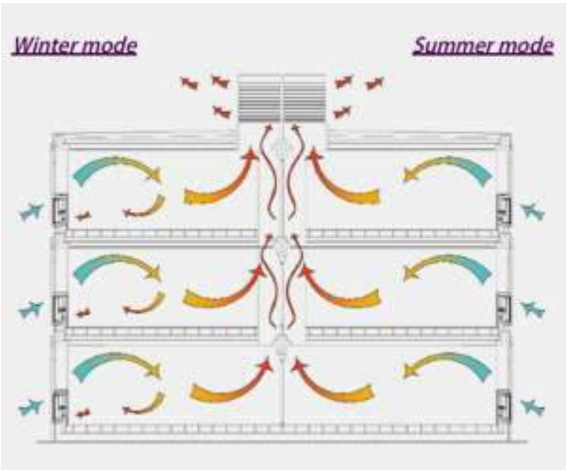


Fig. 134 Buoyant ventilation principle

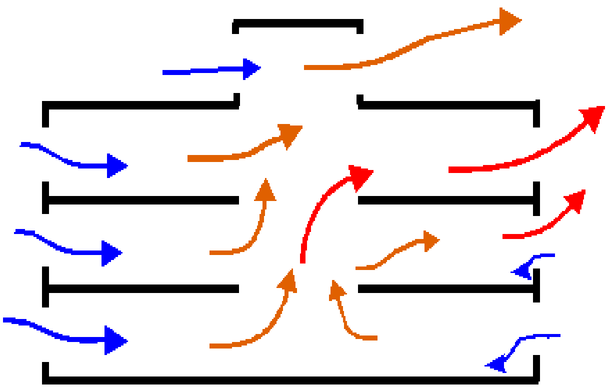


Fig. 135 Scheme of air transfer

Example

Taipei Public Library which is located in the Beitou Branch was nominated as one of the 25 most beautiful libraries in the world. The public library applies outward- opening windows, one on the top and the other in the bottom. This opening of windows creates buoyancy effect and it produced buoyancy driven ventilation. This process not only saves energy but also improves the indoor air quality of the building. Ventilating this building requires an air conditioner, but this air conditioner is only used till October and the reason it is used in the first place is to reduce the indoor air temperature because the normal air temperature of the building from the inside is 28 degrees.

Fig. 136 Example of air flow control

Night Ventilation

Night-Purge ventilation can mostly be used in situations where daytime air temperatures are too high to be used for ventilating the interior of the building but night time air is cool or cold. This strategy can provide passive ventilation in weather that might normally be considered too hot for it. The success of night-purge ventilation is determined by whether additional cooling and ventilation systems were used and by how much heat energy is removed from a building.

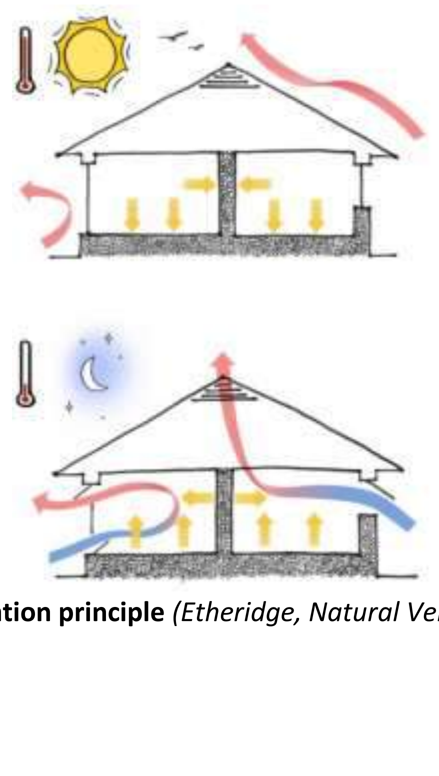


Fig. 137 Night-Purge ventilation principle *(Etheridge, Natural Ventilation of Buildings 2011)*

Night-Purge ventilation works by opening up pathways for wind ventilation and stack ventilation throughout the night so that the thermal mass inside a building could be cooled down by convection. Early in the morning when the temperature begins to rise the building is closed and kept sealed throughout the day so that warm air from outside would not enter. During day time, the cool mass absorbs heat from occupants and other internal loads. This is done by radiation, convection and conduction.

The principle behind this scheme is that a building is required to have large areas of exposed internal thermal mass (Figure 4), because the "cold" is stored in thermal mass. Therefore, the interior should also have little to none interior pieces such as carpets, coverings, many cupboards and panels, ceilings with drop-panels. Using natural ventilation would require relatively unobstructed interior so that air flow could be promoted.

Night cooling refers to the operation of natural ventilation at night in order to purge excess heat and cool the buildings fabric. A building with sufficient thermal mass, which can be exposed to nighttime ventilation, can reduce peak daytime temperatures by 2° to 3° using this strategy. Night cooling offers the potential to minimize or even avoid the use of mechanical cooling and improve the internal conditions in naturally ventilated buildings. Good control of night cooling is required in order to achieve maximum free cooling whilst avoiding overcooling and subsequent re-heating or thermal discomfort the following day.

Example

One of the best known materials which absorbs energy, stores it and then releases large amounts of heat is concrete and masonry. The best thing about concrete is that this material is used in the main structure of most buildings therefore no additional materials have to be used to make the thermal mass. Using thermal mass as a way of ventilation will result in less energy usage, shift of energy demands.

Fig. 138 Example of concrete nad masonry building *(Concrete Thinking 2014)*

Cross Ventilation

The wind generated pressure is complex but basically it is positive on the windward side and negative on the roof and leeward side of the building *(Fig. 139)*.

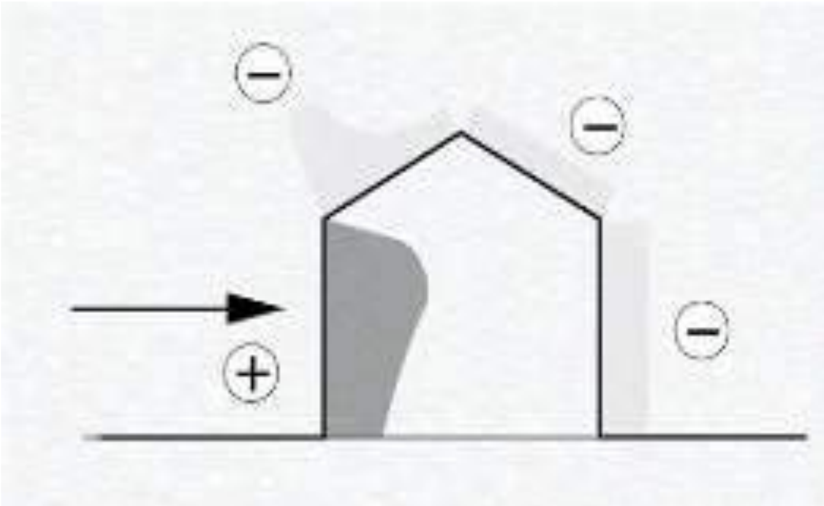


Fig. 139 Scheme of pressure created by wind *(The Royal Institute of British Architects 2009)*

Complex pressure distribution on buildings is generated by wind, particularly in urban environments. This assists ventilation, provided that openings are well distributed and there are available flow paths within the building *(Fig.140)*.

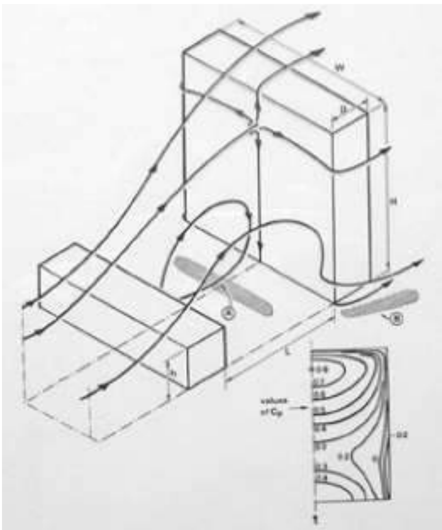


Fig. 140 Scheme of wind movement *(The Royal Institute of British Architects 2009)*

Wind-induced ventilation uses pressures generated on the building by the wind, to drive air through openings in the building. It is most commonly realized as cross-ventilation, where air enters on one side of the building, and leaves on the opposite side, but can also drive single sided ventilation, and vertical ventilation flows.

When wind meets an obstruction such as a building, it is deflected and due to its momentum this creates positive and negative pressures over the surface of the building *(Fig. 139)*. The pressure distribution map is complicated and non-uniform, even over an individual surface *(Fig 140)*, but is generally positive on the windward side and negative over the roof and leeward side. Ventilation air will flow between any two points on the envelope at a different pressure provided there is an opening in the envelope at that point.

How to Use Cross Ventilation?

The correct strategy in modern buildings is to build the envelope so that it would be airtight and ventilate it intentionally with controllable openings. Openings will typically be windows, controllable slots, grilles and louvers. Wind-driven ventilation is capable whenever a building is exposed to the prevailing wind.

There are of course exceptional site conditions like noise and pollution. These conditions prohibit the use of openings in the envelope adjacent to the occupants. Also in dense urban areas, heavily vegetated sites, the prevailing wind might be of a too low speed.

- Wind speed and direction is very variable. Openings must be controllable to cover the wide range of required ventilation rates and the wide range of wind speeds.
- The more the opening area is distributed, the more likely it is that there will be a pressure difference between openings to drive the flow – i.e. many small openings are better than one large opening
- As with stack ventilation, the internal flow path inside the building must be considered.
- For cross-ventilation, bear in mind that the leeward space will have air that has picked up heat or pollution from the windward space. This may limit the depth of plan for cross-ventilation.
- If windows are used, consideration must be given to their controllability and ergonomic design, and the effect of air flows to the immediately adjacent occupants

Advantages of Using Cross Ventilation

There are two mechanisms by which natural ventilation is driven, ventilation because of wind and the other being the stack effect.

Natural ventilation as an alternative to mechanical ventilation has several benefits:

- low running cost
- zero energy consumption
- low maintenance and probably lower initial cost
- regarded as healthier
- less hygiene problems with ducts and filters

Spatial Configurations of Rooms

The overall special configuration of the building, rooms plays an important role. The set configuration determines the flow of air in the area. It is important to avoid harsh draughts *(Fig. 141)*.

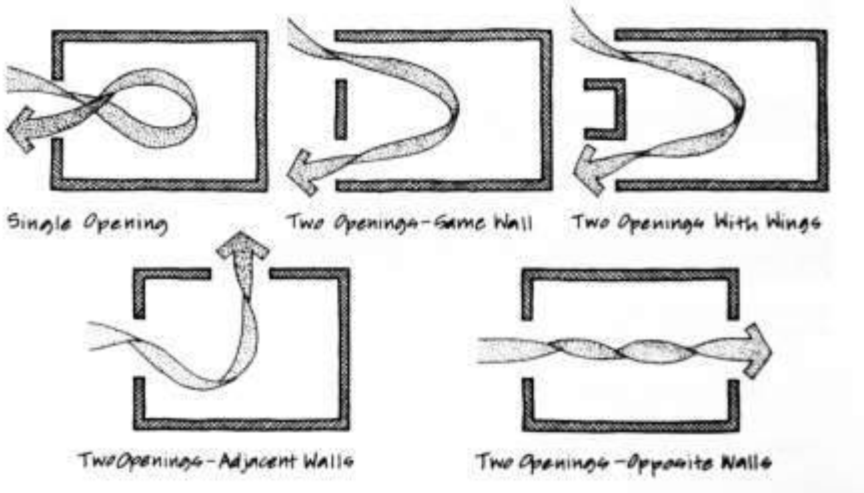


Fig. 141 Scheme of air paths *(The Royal Institute of British Architects 2009)*

Example

The Environmental Protection Agency which is located in Region 8 Headquarters, Denver, Colorado and was designed by Zimmer GunsulFrasca Architects is known to have received a Gold LEED rating. It is a good example of cross ventilation system. This building has an under-floor air distribution system which is used throughout all office floors. This lets air to flow through the buildings envelope and cool the building. Also the openings of the floors are fully controllable so the inflow of air can be adjusted to get the most out of this type of ventilation system.

Fig. 142 Fascade of the Enviromental Protection Agency *(Green Team 2013)*

Conclusion

The main force behind buoyancy driven ventilation is air. Of course the air has to be hot, well of higher temperature than the air below the warmer mass of air for the physical phenomenon of convection to occur (Fig.135). It has some defined rules where this system can be installed and the cost to achieving this is initially more than to build mechanical ventilation system but there are basically no maintenance costs. This makes the natural system more beneficial to the well-being of the inhabitants in the ventilated building and in the long run the will be saved and might even be earned from this type of natural system.

Night time ventilation can be closely interpreted as convectional (buoyant) type of ventilation which is also basically ran by movement of "hotter" air which is possible by placing ventilation ducts and windows at specific places to make flow of air possible inside the building. But this system has to be closely watched over or it needs to be a mechanized, because only during the night time air needs to enter the building because it is in cool condition and it will push the warm air out which is outside. Also the building's interior has to have an exposed large thermal mass because the warmth and the cold are going to be stored there. But there are drawbacks too. Weather changes influences whether the windows or ducts can be opened so that the interior of the building would not be damaged. Temperature is also not a stable unit which is changing constantly so it might be risky to install this type of system.

Cross ventilation is driven by power of wind. Ventilation is possible by making controllable openings (Fig149) in the envelope of the building. Also some specific regulations regarding the interior arrangement of walls has to be taken into consideration because otherwise wind will not flow. Also some specific requirements have to be taken into consideration for the envelope itself. The envelope has to be airtight and the ventilating needs to be controllable. The maintenance cost is lower in comparison to the mechanical ventilation. However, evaluation of the site has to be made, in order, to determine if the site is eligible for this type of ventilation. Evaluation includes sound and air pollution matters, overall urban plan to determine if wind is present, speed and direction of wind appropriate.

General Conclusion

The study of geopathology started many years ago and still doesn't stop nowadays. Many professionals are trying to solve this problem and a lot of architects trying to avoid plots where they find any slightest hint on it. Huge amount of equipment where used in previous and it developing to a huge amount of technologies that are used nowadays. I'm sure that people won't stop on that and we could make the heaven on Earth.

The light that we receive from the sun is altered by the atmosphere, from all the light that is initially sent by the sun, more than half is reflected or absorbed before it is received by the earth. The orientation of buildings depends largely on the solar radiation during the day.

Passive solar design tries to optimize the amount of energy that can be derived directly from the sun. The best part about Passive Solar applications is that they have no moving parts. They can perform effortlessly and quietly without mechanical or electrical assistance. Most design consideration can be made and implemented using standard building materials and basic construction skills. All these lead to lower annual bills and also improve the comfort of living spaces. Simple techniques, that were presented today, he can make a huge difference in the comfort and energy consumption through the years and the way of living.

Considering the air infiltration, air leakage should not and cannot be eliminated, but sealing window and door gaps can reduce it to a minimum. To avoid inappropriate temperatures in rooms one should have in mind window-to-wall and window-to-floor ratios that are from 20 to 40%. What about humidity and temperature levels, a person feels best when the humidity is about 45% and temperature is between 18 to 24 degrees Celsius.

Heat losses occur through conduction in the walls, floor, roof, windows and doors or via ventilation in the form of air leakage. It can be reduced in several ways. The exterior wall construction and the geometrical shape of the house can help the environment, and it can save you a lot of money. Also heat loss occurs in a house with drafts wind blowing against an end wall. The most innovative way to reduce heat loss is by higher thermal inertia and phase changing materials (PCM) which collect and store heat throughout the day, and then slowly release it as the temperature drops by changing its material.

Main goal of physiological cooling is to achieve thermally comfortable environment for humans. There is variety of methods to achieve the human physiological comfort, and throughout the years, the ways of manipulating human temperature have become more diverse and effective. Controlling air flow, using natural winds and controlling draughts and breezes are some of the possible ways to affect human body temperature. Besides striving for human thermal comfort, it is also equally important to consider air quality in the enclosed space that architects design.

Air cooling is needed in every building and for people living in the building. Natural ventilation is really important and eco-friendly types of ventilation which should be picked by people. Only few problems are with natural ventilation: less energy consumption so that means that the hot climate is a challenge to ventilate. But there is a way to use evaporative cooling which is a really great concept of air cooling. It makes the area more humid and more refreshing and cooled. As it was mentioned, air cooling is really important, the text should have proved that why is air cooling important, for what it is used for and what kind of air cooling should be picked to save our planet Earth.

Buildings that have natural ventilation systems installed are friendlier to the environment. They can sustain themselves because these systems of ventilation do not consume large amounts of electricity. These ventilation systems can be used to make electricity using flow of air generated inside the system. Because of maintenance costs in certain amount of time it is cheaper to not have mechanical ventilation in buildings. Air which is a product of natural ventilation is better for your health than air coming out of mechanical ventilation systems. The well-being of people inside the building is also improved with better quality of air.

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