<u>MSc IN ENERGY SYSTEMS AND THE ENVIRONMENT</u>

Department of Mechanical Engineering

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A Strategy for Sustainable Development of the Built Environment for the Mediterranean Climate

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1. ABSTRACT

The dreamed house to satisfy human needs, technology and ecology is not a privilege and this text presents an overview of how an ecological house does not necessary require more money, just more thought and planning, more innovation and knowledge to use the resources in a sustainable way. Our homes have to be comfortable, healthy and meet all our varied demands.

The criteria followed are not only aesthetic, ecological and economic, other considerations as the new methods and the lifestyles are taking place and more importance each day. The urban development has an important task to establish a new vision for the built environment founded on principles as the design excellence, social well-being and environmental responsibility, all this to achieve a sustainable urban design and to promote the ecological and bioclimatic constructions.

It is important to show an integral and complete vision of the urban development in which the urbanism, transport, landscape, energy, buildings, environment and citizens are all interrelated and integrated.

The concept of ecologically friendly building can be interpreted in different ways by builders, architects, engineers, ecologist, politicians and citizens. In general, ecologically buildings describe a kind of building which respects the nature and the biological processes. Other commonly term is green buildings, eco-houses and sustainable designs and obviously, the main goal is to reduce the negative impact that

the building has on the environment, and to decrease the amount of energy consumed and with this, decrease the capital and environmental costs.

The main meaning is to use natural materials for healthy lifestyle and one of the most important criterion would probably be to choose only renewable materials as wood, which have not been treated with toxic, health threatening substances. By this reason, buildings should not only be energy efficient, it would be important the use of materials whose manufacture has minimal impact on the environment. In this way considerable care and attention must be paid to the use of renewable raw materials, simple technology that can be more easily repaired or replace, as well as recycling.

Engineers and architects who specialize in solar energy designs believe that all the houses should be designed to receive and use the energy of the sun. If all the energy generated by the sun were used to its full potential, buildings could be transformed from energy users to energy producers.

New buildings must be integrated into the existing towns and surrounding countryside. Every effort should be made to ensure that more and more people have access to housing that promotes health and is affordable both initially and in long term. The main idea is that the construction methods must comply with the demands of ecology and the preservation of environmental as well as human health.

It is possible to show an evaluation of the most important factors to consider in building design as the current building materials, the modern construction techniques, new sustainable strategies to be followed, the ecological aspects in construction, the relation with the environment and the citizens, and every aspect focussed on the Sustainable Development for the built environment. The environment and the way we live in it are linked and it is important to achieve a strategy containing every element that has to be taken into consideration when designing, constructing and, indeed, living in buildings according to ecological and environmental principles.

It is not necessary to think only about high technology homes, it is rather the small things, the simple ideas and easy but effective guides and methodologies have to be selected as it is shown in the case study presented in the thesis.

Firstly, this text is going to present an overview of every important topic about the sustainability in the built environment, all concerning to the ecological and friendly elements in buildings and healthy aspects. Secondly, it is going to propose an strategy for sustainable development in the built environment for developed countries and the last part is going to show an example with a case study of bioclimatic construction in Spain.

The purpose of this text is to give general idea about this theme and to create a clear concept for bioclimatic and ecological construction in nowadays and thinking about our future.

2. SUSTAINABLE DEVELOPMENT IN BUILDING DESIGN

"Sustainability means preserving the future"

Sustainable building is the term used when people is talking about a building carried out according to environmental and ecological perspectives.

The term Sustainable Development was defined in 1987 by the World Commission on Environment and Development as that "which meets the needs of the present without compromising the ability of future generations to meet their own needs". We have to act in such manner that the future generations are not affected in any way.

The sustainability in buildings refers to the effects of buildings on the environment from the production of building materials and construction of the building to the use of ecologically and non toxic substances in buildings, and finally considering the possible demolition of the building at the end of the useful life.

Sustainability is a complex word and involves a lot of conceptions and considerations but one of the most important questions included in the meaning of this word is the tolerance of ecological pressure in buildings.

The local necessities and the costumes of the people in each country or area are different but everybody dream with a comfortable house in the countryside, in a semi-rural area or even in the city centre, depending on the preferences and necessities of each one. The level and quality of life in different countries are different and the same happens with the ownership in the developed countries. While in some European countries most families are homeowner, in Germany, for example, only 40 % of Germans own the home where they live in. Other aspect that it is different in countries and depends on the local necessities is the space available to each resident. One data[1] is that the number of single-person households in the major of the European countries rises every year and this is due to the fact the habits and lifestyle of people are changing.

The pressures on the market for housing, to rent as well as to buy, increased in the 1990s as a result of the increasing numbers of people in the 20-35 age groups. The number of renting is greater than the number who owns their home. For this reasons the demand of living spaces is rises considerably day by day. People necessities are changing along the life and with this the place where they live. This idea help us to think about the different kinds of homes that we need along our live, when we are children, when we are independents and we want to life alone and after that when we have a family. By this reason it is important to think about to adapt our living space for each period of our life, to create a flexible and changing home to life and don't change to new home spaces along our life to reduce the new constructions.

Each year more rural area is converted to urban development; urban areas where people meet their primary necessities are growing. In this way urban surface is created concentrating a lot of people, buildings, offices, shops and generating traffic.

Housing developments come now near the goal of creating compact communities with balanced multi-generational and supportive neighbourhoods. With an optimum strategy it is possible to ensure that tenants of different ages and from different social strata could live together creating a more diverse community.

[1] 1990 US Census Data. Time Saver Standards for Architectural Design Data. Mc Graw Hill, Inc, 1990

For sustainable development it is important to optimize the available space, the minimum destruction of existing vegetation, concentrate population and conserve resources. Related with this it is important to think about the distances. The physical segregation of our working, living and shopping lives has been made possible and encouraged by technological advancements in transportation.

People who live in the city and in the countryside are moving every day from one place to another. Nowadays, the distances covered for working and shopping have increased due to the growth and development in urban areas. All this makes cars the greatest polluters of urban development and the changes in personal mobility have to be considered to establish a building policy to take this into account and to make an effective control.

The question is whether we are going to continue increasing the traffic in volume or we are going to be more responsible with the transportation needs and land use reducing the distances. Transport has a major impact of carbon dioxide emissions and on the sustainability of housing and communities. If people is serious about sustainable development they must be serious about transport policy, and reducing pollution.

Returning to the sustainability the most important thing to start is to build energy-efficient and non-toxic houses. The surest way to conserve resources is to combine spaces and not to build unneeded space in the first place. Of the common maxim, "reduce-reuse-recycle", reduce is quite clearly the best choice and it is also the most effective way to reduce costs.

Talking about these options it is possible to pay attention in the possibility to build recyclable houses. Obviously by reusing buildings rather than demolishing and building new ones, construction waste can be significantly reduced.

Restricting the choice of building materials to non-toxic, long-lasting, easily obtained and also easily repairable material facilitates planning and construction while producing a building that is less harmful to the environment over its life. It certainly makes sense during the design phase to separate components that will require early replacement or servicing, such as interior decor, from the more permanent and long-lasting materials used for the structure and shell of the building. The number of different materials should be kept to a minimum, and those that are used should be carefully selected to ensure that they contain as few toxic additives as possible.

One should also begin to examine possible ways of use recycled or reused materials from other buildings for various components house hold fixtures and fittings. Many building materials available today contain either pre-consumer or post-consumer recycled materials. Although there is not yet widespread agreement as to how recycled-content building materials should be defined it is a good idea that products have a label with a relative environmental impact index so that the costumers may make the best possible choice.

Only natural building materials without synthetics, such as natural stone, wood, wood wool and wood fiber, clay, straw, flax and others can be considered as "globally recyclable". These materials can be produced without a great deal of energy and there are not as many problems with environmentally harmful by-products or waste.

Good energy efficiency homes provide better environments for people living in them as well as reducing the impact on the natural environment. In the domestic sector the carbon dioxide emissions are high and much of it through the heating. It is essential to reduce these emissions improving new designs and also by tackling existing housing that has poor energy efficiency.

With such a wide range of issues to consider, we need to develop new, flexible tools to help us assess the quality of housing, and ensure that it provides value for money. By all these reasons we are going to propose a group of sustainable indicators, which could be used to evaluate all the factors that are crucial to the design of high quality sustainable housing.

In conclusion, for a sustainable development in housing we need to consider the last issues and to be sure about the combination of environmental, social and economical activities to achieve a good progress for sustainable houses and sustainable communities in general.

3. ECOLOGICAL HOUSES

To give an idea about what is an ecological house it is necessary to consider several aspect which can be used as a guide to understand this kind of buildings and it is possible to use them to know the basic characteristics of these houses. These aspects are the healthy and comfort, the use of ecological and natural materials, the energy efficiency, the use of renewable, and the home technology which can be more expensive and difficult to apply.

In the next points a general idea about these aspects is shown. Only we want to show an easy guide without more details, only to keep people informed about the possibilities that it is possible to apply in our own home or in future buildings to have a natural and ecological house.

3.1. Healthy homes

When people is talking about health for houses, the main concern is the direct effect that the indoor environment has on the occupants and other things in the house. It is necessary to feel healthy and comfortable in the house. The comfort can be expressed in numbers and it defines the basic human needs precisely. It is not only the failures of old building methods but also of the current building design and construction practices in nowadays that dangerously compromise our health[2].

It is important to establish precisely the optimum conditions to create a comfortable indoor environment. The main comfort conditions to be considered are:

- An appropriate temperature
- An appropriate relative humidity
- Air quality and movement
- Ventilation

[2] "The New Natural House Book". Pearson David

With an adequate strategy, favourable in ecological terms, it is possible to reduce the amount of energy consumption with high efficiency heating and cooling systems, well insulated constructions with wind protections, with other measures in doors and windows to avoid the air infiltration, windows with highly efficient glazing and the use of surfaces with substantial thermal mass and good heat retention. And all that contribute to the well-being of the occupants of the building.

Nevertheless, and considering other pathologies observed in buildings today it is necessary to add other factors or conditions to be analysed as the natural lighting, the electrosmog pollution, the acoustic pollution, the presence of microorganisms and others.

One of the most important aspects for homes is that they have to be properly ventilated, even though this can result in a loss of energy. Building ventilation is necessary for supporting life by maintaining acceptable levels of oxygen in the air, to prevent carbon dioxide CO_2 from rising to unacceptably high concentrations and to remove odour, moisture and pollution produce inside of the house.

Although CO_2 is not considered a harmful gas, nevertheless a high CO_2 concentration is the same that deficient oxygen levels in the air. The concentration of CO_2 was considered by many as the criterion for admitting fresh air into a building. We can't doubt about the sustainability of CO_2 concentration as an index of air quality. Research have shown that, in modern buildings, other pollutants can be more important in terms of quantities produced and their impact on human health but the reduction of CO_2 emissions in the built environment is one of the most important tasks to be achieved[3].

Other important aspect in buildings is the absence of natural daylight which can cause a genuine illness known as seasonal affective disorder, experienced by many people during winter months and particularly in northern latitudes[3].

Lack of adequate daylight in buildings has also been associated with elevated stress levels, and other facts. Even today, apartment buildings are being built in which the

[3] 1 Congreso Nacional de Calidad Ambiental en el interior de los edificios.

units receive light only from the north or the east, which means, of course, that the sun will never shine directly into them. It is not convenient that living-room, kitchen, dining area where we spend a lot of time, only have electrical lighting. By this reason is necessary to know about of the need for natural light in buildings[4].

In general, healthy living is possible only in healthy surroundings. When the site for a new house is chosen, it is important to investigate subsoil characteristics as contaminated soil, natural radioactivity which can cause a serious air pollutant known as radon gas, electromagnetism, and other aspects of the immediate surroundings as the traffic noises, hazardous emissions of pollutants and power lines that might have a negative effect on our health and well-being.

It is important to create an architecture that promotes health. The external design of a house is often based on traditional architecture modified to take into account the inherent characteristics of the building's surroundings. Considering the local climate conditions and the integration of the new building with the surrounding it is possible the creation of a harmonious environment. It is important the style in which a house is built and the basic design, the colour, the surface structure and the layout of the rooms.

A building which responds to the local climate and expresses the warmth of natural materials and of it promotes a sense of well-being and serenity to its users. In practical terms it can be started that natural materials such as wood are pleasing to the touch, natural stone imparts a feeling of security, paint free from chemical additives has a more agreeable smell and natural textiles create a more pleasant atmosphere, in general making the residents feel at home.

A healthy living environment includes comfortable scale and proportion, clarity in layout of the rooms, contrasts in lighting variety of views, well landscape surroundings and a return to the traditional methods in design and constructions.

[4] "El Gran libro de la casa sana". Mariano Bueno. Nueva era, 1992

3.1.1. Sick Building Syndrome

Modern building techniques have been influenced by the idea about that anything is possible and just because something new is discovered, does not make a better idea. One example is the modern materials used in buildings which were developed through advances in the petrochemical industry at quite a considerable cost in terms of energy and environmental damage. Over time it has become apparent that many of these materials are unpredictable and even toxic.

Other important aspect is to be conscious that a healthy building is only possible if poisonous substances and materials are avoided, the basic human needs are considered, the necessity to study the surroundings, the presence of plants, trees and in general to create an interrelation between the environment and the residents.

People living in industrialized countries are threatened everyday by a highly toxic cocktail made up of chemical and synthetic materials. To make matters worse, we still know very little about the precise effects they have on our health.

Everyday items found in the home, such as furnishings, carpets, paints with additives, asbestos, wood preservatives, and others can be harmful to our health. We come into contact with more and more chemicals all the time, and they are causing irreparable damage to our immune systems.

One important aspect to consider is the Sick Building. When a building is the cause of illness, the term generally used is building related illness (BRI) and if the cause can not be established with absolute certainty, the term applied is sick building syndrome (SBS)

A "**Sick House**" is defined as a house that causes sickness to the people living in it and its surrounding environment. Some causes can result from their use of building materials containing chemical substances that cause sickness such as allergy.

The Sick Building Syndrome (SBS) term is presented when we talk about the method used in ventilating a building, whether air-conditioning or natural ventilation should be used, as well as the quantities of fresh air supplied to a building but other factors are also related and have a big influence too. The lack of fresh air is a contributory factor but not necessarily the main cause of SBS.

Contamination of indoor air in houses has now become a big problem, causing people to be concerned over the adverse effects of the indoor environments on their health. There are harmful substances existing in our homes that cause several symptoms of sicknesses. With the disorders the term syndrome is used to indicate a collection of apparently unrelated symptoms. More is being learned each day about these disorders, but one thing is certain, the cause is related to our increasing exposure to chemicals in the environment.

HEALTH EFFECTS
Allergies
Easy fatigability, chronic fatigue
Lowering of memory/thinking power
Irritability
Inability to fully awake in the morning
Headache, occipital pain
Explosion of anger and emotion
Lowering of judgment/attentiveness
Lowering of will to work or live
Difficulty in sleeping/sleepiness at daytime

Table 3.1.1.1. Health effects. “The New Natural House Book”. Pearson David

It is necessary to investigate the complex interrelationship between the chemical and the biological pollutants and other environmental factors. Noise and high ozone levels caused by cars have a detrimental effect on people, even when they are in indoor environments. The most common air pollutant inside buildings however is the tobacco smoke. Cigarette smoke contains more than 10000 different substances that could cause health problems; these include formaldehyde, hydrocarbons and others.

Other dangerous chemical are the pentachlorophenol (PCP) and lindane, both used as pesticides in wood preservatives and also to treat leather. More common hazards to health in the home is from volatile organic compounds, mainly solvents found in adhesives, varnishes, paints, including toluene, sylene, acetone, methanol, methylethyl ketones, as well as CFCs between others.

We can propose a classification of the main pollutants that we can find in our own home. In the next table is possible to see the main indoor air pollutants and their sources and potential effects.

Sources and Potential Health Effects of Indoor Air Pollutants

Pollutant	**Major Indoor Sources**	**Potential Health Effects***
Environmental Tobacco Smoke	Cigarettes, cigars, and pipes	Respiratory irritation, bronchitis and pneumonia in children, emphysema, lung cancer, and heart disease
Carbon Monoxide	Unvented or malfunctioning gas appliances, wood stoves, and tobacco smoke	Headache; nausea; angina; impaired vision and mental functioning; fatal at high concentrations
Nitrogen Oxides	Unvented or malfunctioning gas appliances	Eye, nose, and throat irritation; increased respiratory infections in children
Organic Chemicals	Aerosol sprays, solvents, glues, cleaning agents, pesticides, paints, moth repellents, air fresheners, drycleaned clothing, and treated water	Eye, nose, and throat irritation; headaches; loss of coordination; damage to liver, kidney and brain; various types of cancer
Formaldehyde	Pressed wood products such as plywood and particleboard; furnishings; wallpaper; durable press fabrics	Eye, nose, and throat irritation; headache; allergic reactions; cancer
Respirable Particles	Cigarettes, wood stoves, fireplaces, aerosol sprays, and house dust	Eye, nose and throat irritation; increased susceptibility to respiratory infections and bronchitis; lung cancer
Biological Agents (Bacteria, Viruses, Fungi, Animal Dander, Mites)	House dust; pets; bedding; poorly maintained air conditioners, humidifiers and dehumidifiers; wet or moist structures; furnishings	Allergic reactions; asthma; eye, nose, and throat irritation; humidifier fever, influenza, and other infectious diseases
Asbestos	Damaged or deteriorating insulation, fireproofing, and acoustical materials	Asbestosis, lung cancer, mesothelioma, and other cancers
Lead	Sanding or open-flame burning of lead paint; house dust	Nerve and brain damage, particularly in children; anemia; kidney damage; growth retardation
Radon	Soil under buildings, some earth-derived construction materials, and groundwater	Lung cancer

(*)Depends on factors such as the amount of pollutant inhaled, the duration of exposure and susceptibility of the individual exposed

Table 3.1.1.2**.** Indoor Air Quality and Personal Exposure Assessment Program.

3.1.2. Indoor Air Quality (IAQ)[5]

- **Indoor Air Problems**

Indoor pollution sources that release gases or particles into the air are the primary cause of indoor air quality problems in homes. Inadequate ventilation can increase indoor pollutant levels by not bringing in enough outdoor air to dilute emissions from indoor sources and by not carrying indoor air pollutants out of the home. High temperature and humidity levels can also increase concentrations of some pollutants.

The relative importance of any single source depends on how much of a given pollutant it emits and how hazardous those emissions are. In some cases, factors such as how old the source is and whether it is properly maintained are significant.

Some sources, such as building materials, furnishings, and household products like air fresheners, release pollutants more or less continuously. Other sources, related to activities carried out in the home, release pollutants intermittently. These include smoking, the use of malfunctioning stoves, furnaces, or space heaters, the use of solvents in cleaning and hobby activities, the use of paints, and the use of cleaning products and pesticides in house-keeping. High pollutant concentrations can remain in the air for long periods after some of these activities.

- **Ventilation**

If outdoor air enters at home, pollutants can accumulate to levels that can be health and comfort problems. Unless they are built with special mechanical means of ventilation, homes that are designed and constructed to minimize the amount of outdoor air that can "leak" into and out of the home may have higher pollutant levels than other homes. However, because some weather conditions can drastically reduce the amount of outdoor air that enters a home, pollutants can build up even in homes that are normally considered leaky.

Outdoor air enters and leaves a house by:

- Infiltration
- Natural ventilation

[5] /www.epa.gov/iaq/

- Mechanical ventilation.

In a process known as infiltration, outdoor air flows into the house through openings, joints, and cracks in walls, floors, and ceilings, and around windows and doors. In natural ventilation, air moves through opened windows and doors. Air movement associated with infiltration and natural ventilation is caused by air temperature differences between indoors and outdoors and by wind. Finally, there are a number of mechanical ventilation devices, from outdoor-vented fans that intermittently remove air from a single room, such as bathrooms and kitchen, to air handling systems that use fans and duct work to continuously remove indoor air and distribute filtered and conditioned outdoor air to strategic points throughout the house. The rate at which outdoor air replaces indoor air is described as the air exchange rate. When there is little infiltration, natural ventilation, or mechanical ventilation, the air exchange rate is low and pollutant levels can increase.

- **Effects on health**

Health effects from indoor air pollutants may be experienced soon after exposure or, possibly, years later.

Immediate effects

Immediate effects may show up after a single exposure or repeated exposures. These include irritation of the eyes, nose, and throat, headaches, dizziness, and fatigue. Such immediate effects are usually short-term and treatable. Sometimes the treatment is simply eliminating the person's exposure to the source of the pollution, if it can be identified. Symptoms of some diseases, including asthma, hypersensitivity pneumonitis, and humidifier fever, may also show up soon after exposure to some indoor air pollutants.

The likelihood of immediate reactions to indoor air pollutants depends on several factors. Age and preexisting medical conditions are two important influences. In other cases, whether a person reacts to a pollutant depends on individual sensitivity, which varies tremendously from person to person. Some people can become sensitized to biological pollutants after repeated exposures, and it appears that some people can become sensitized to chemical pollutants as well.

Long-term effects

Other health effects may show up either years after exposure has occurred or only after long or repeated periods of exposure. These effects, which include some respiratory diseases, heart disease, and cancer, can be severely debilitating or fatal. It is prudent to try to improve the indoor air quality in homes even if symptoms are not noticeable.

While pollutants commonly found in indoor air are responsible for many harmful effects, there is considerable uncertainty about what concentrations or periods of exposure are necessary to produce specific health problems. People also react very differently to exposure to indoor air pollutants.

- **Indoor and outdoor air pollution**

Indoor air pollution is caused by an accumulation of contaminants that come primarily from inside the building, although some originate outdoors. These pollutants may be generated by a specific, limited source or several sources over a wide area, and may be generated periodically or continuously. Analysis of indoor environments reveals that more than 900 different contaminants may be present, depending on the operations specific to the environment.

Major sources of contaminants can exist both outdoors and indoors. Outdoor air contains myriad contaminants including chemicals from fugitive industrial emissions, vehicle exhausts, atmospheric photochemical phenomena, agricultural activities, and bioaerosols from natural microbial growth. These contaminants make their way indoors through ventilation intakes, open doors and windows, and leaks in the building envelope (or infiltration).

Typical sources of contaminants unique to indoor environments include volatiles and particulates from building materials, furnishings, appliances, office equipment, office/residential cleaning supplies, human activities (bioeffluents), tobacco smoke, biological organisms, and pesticides. Other contaminant sources include the components of heating, ventilating and air-conditioning (HVAC) systems, such as filters, duct boards, condensate drain pans, humidifiers, cooling towers, refrigeration equipment and fuel burning equipment. Poor design, installation and maintenance of

HVAC systems may introduce combustion emissions and bioaerosols into the indoor environment.

It is the unique combination of physical factors, indoor air pollutant species, and rate of emission, and ventilation inadequacy that causes indoor environments to provoke adverse human health effects.

- **Environmental factors**

Contaminants usually do not act alone in affecting occupants' health. General physical and environmental conditions, such as temperature, humidity and lighting, may interact and intensifies the problems. Besides the factors that directly impact the levels of pollutants to which people are exposed, a number of environmental and personal factors can affect how people perceive air quality. Some of these factors affect both the levels of pollutants and perceptions of air quality. A better understanding of the effect requires the study of the four basic sensory receptors of human beings: olfactory, auditory, thermal and visual.

The factors that express themselves in a sensory awareness are not perceived by all occupants in exactly the same way, and even for a single occupant the perception of a given factor will vary over time. As a result it is usually not possible to identify values for these factors that will be acceptable to all occupants. Factors that are characterised by such an ability to indicate absolute acceptable values are:

- Those directly affecting IAQ, like odour, irritants, room temperature, relative humidity, and air velocity.

- Those affecting satisfaction with the overall indoor environment, such as lighting, noise furniture and equipment, building vibration and motion, crowding and personal work space, psychological and ergonomic factors (causing stresses and no comfort).

Three general categories of occupant responses

Type of response	Typical examples
Perceived and result in physiological strains	Warm and cool air, odourous gases and vapours, irritating glare, and noise
Not perceived but cause physiological strains	Odourless gases and vapours (carbon monoxide, radon), carcinogenic compounds, gases and vapours with odour recognition thresholds above irritation thresholds (formaldehyde, ozone), inert particulates (asbestos, glass fibres), and bioaerosols (bacteria, fungi, spores)
Perceived but do not cause physiological strains	Labour management climate, collegial relations, privacy (the lack of it) and job satisfaction

Table 3.2.1.1: Indoor air quality web site[6]

- **Acceptable Indoor Air Quality**

IAQ Standard in USA, *ASHRAE (Standard 62-1989*) is useful to define an acceptable IAQ as an air in which there are no known contaminants at harmful concentrations and with which a substantial majority (80% or more) of the people exposed do not express dissatisfaction. This definition include to measure concentration of contaminants to prevent illness and to measure comfort conditions as odour, temperature to provide comfort.

3.2. A natural house

Natural home means building with respect for the nature. It should adapt to the existing conditions of the land and the used materials should, wherever possible, be obtained from renewable sources.

Depending on the location in high, cold mountains it is possible to find wood and stone buildings protected from the snow and rain. By contrast, houses in coastal regions have reef roofs to provide effective sheltering against the wind and spray. In humid regions ventilation systems and in hot areas thick stone or clay walls offer protection against the heat and the sun.

[6] http://arch.hku.hk/teaching/lectures/iaq/

Depending on what natural resources could be found locally, buildings would typically be constructed of brick, stone or wood, clay and others.

The process of industrialization has meant that traditional building methods have largely been superseded. Extremely strong and lightweight supporting structures, prefabricated and mass-produced components, a wide range of synthetic and engineered building materials, as well as centralized heating and ventilating systems, reliable electrical lighting and indoor plumbing have changed the building industry.

Yet the introduction of modern methods and materials means that homes are typically no longer built in sympathy with the environment nor responsive to the climate conditions, and they include far fewer natural materials. This has to be changed. There are architects who believe in environmental principles and in a green design for houses even creating a biotype. This is a shortsighted view of ecology because it is known that population is growing and the urban areas are in expansion but not with single family houses. The development is going towards high constructions, vertical high building with a vertical growth minimizing the use of the land and we have to find the relation between this development and the green constructions.

For a building to be considered sustainable it must be both, energy and resource efficient. Efficiency means achieving the greatest personal comfort and utility with the least possible depletion of natural resources.

3.2.1. The site and the local materials

Topography has a considerable influence on the local microclimate and so is a major consideration when we have to choose a site for a new house. For example, in a valley mists can reduce the amount of solar energy available. The ideal site would be on a slope, preferably a south-facing one. An important goal will be to alter the environment as little as possible.

Trees close to the building offer considerable protection against the weather as well as shade from unwanted summer sun, and the excavated soil can often be used to construct in an effective way of diverting winds.

It is also important to remember that major openings, such as doors and windows, should not face into prevailing winds. Further energy savings can be achieved by installing the external doors so that they open out-wards, this allows the positive pressure of wind blowing against them to ensure the best possible seal against air-leakage. It is necessary to know that a building which totally ignores the sun's rays can require as much as 50% more energy to heat and cool than a similar building designed to take advantage of the sun's energy. In order to ensure the positive thermal effects of the sun it is important that the path of the sun and the angle of its rays be taken into account for the entire year.

Site sensitive design will include considering the ecology of the site, the slope and its directional orientation, water features and climatic characteristics, to name a few. An important goal will be to alter the environment as little as possible.

One important point to consider in the site is the rainwater system. It is possible to think about how to recover this water which is going to the land without any other use. Rainwater can be collected and stored in cisterns and use for other purpose around the home such as watering gardens and flushing toilets.

This practice would not only reduce the capacity requirements on remote water delivery systems and reservoirs, but would also save money overtime.

Other aspect is to make composting on site to maintain a fertile soil and the natural cycles in our environment. Human and food waste need not simply be thrown away. It can be turned into compost providing value humus for gardens and flower beds and thus become a contribution in the ecological cycle. The expensive septic and sewer system may seem essential for the sanitary disposal of waste, however, commercially available systems can now be found to provide a safe, non-smelling ecological alternative. These systems can help to reduce the need for enormous sewage plants that produce high quantities of toxics.

- **Natural materials**

Using natural materials is always a better option than using synthetic ones when it comes to building. This is not always the case because these materials are often to be found in very remote regions of the world and have to be transported over large distances to get them to where they are to be used. This common practice results in excessive expenditures of both capital and energy. By this reason we have to think in the local natural materials, materials which can be regenerated. Following these precepts we would have different consequences in each land around the world. Depending on the place we can have as traditional materials the cotton, the cork, woods, etc.

Wood has been a building material of choice for thousand of years. In the northern countries and in USA wood is used in the majority of buildings whereas in the countries bordering the Mediterranean wood has only a very minor role in building for example.

Wood is a natural and renewable material and also has a very positive impact on air quality by converting carbon dioxide, a greenhouse gas. It is an environmentally friendly building material, but the use of woods has to be sustainable for example we have to know that not all woods have the same behaviour. Tropical woods are more easily worked, straighter and almost without any branches and often more pleasant to look at and more weatherproof than most temperate woods but the problem is that are very slow growing and very difficult to replace.

Nowadays there is a growing tendency to use synthetic materials that are harmful to the environment and an example is the PVC for windows replacing the wood windows. It is important to know that this is not the solution.

- **Other renewable materials**

Sheep wool, straw, flax, bamboo are renewable materials which are more suitable for buildings products. Sheep wool is highly suitable as a non-synthetic floor covering and as insulating material. Wool can frequently contain a wide variety of chemical pesticides used during storage and transport. Non toxic carpets that are classified as manufactured from pure virgin wool use the less objectionable pyrethroids (obtained from natural sources) for mothproofing.

Straw bale as a construction material is becoming popular in some regions. Solidity, a high thermal resistance, low cost and non-toxic renewable source of grain agriculture make straw bales an environmentally responsible building material. It is usually locally available, inexpensive and long lasting. It is also an esthetical pleasing material, lending itself to soft curvature in building form, soft finishes and deep window recesses which speaks of sustainability. Straw has also been used to manufacture structural insulated panels, ideal for the panellized rapid construction of the walls, roofs and floors of a house.

Water reeds, flax, bamboo and others are used as building materials. For example flax has been cultivated in Europe to commerce. It is simple to grow and its seeds are used to manufacture linseed oil, an indispensable ingredient in linoleum flooring and in many paints, and its fibres are also used in the production of insulating materials and clothes.

Other organic building materials include a wide range of oils, resins and other substances. Also natural grown pigments and chalks are used in the production of non-toxic clays and paints.

- **Non-renewable natural building materials**

Besides organic renewable raw materials, minerals may be counted as natural building materials. An example is the natural stone. A lot of types of sandstone, limestone, granite, marble and slate can be found. They have been used to build walls, floors, foundations, windows and door surrounds. Nowadays they are used as flooring material, facade, wall veneers and ornamentation.

For longevity, beauty and the health benefits of using non-toxic materials, stone is unequalled. However, processing, finishing and transport of stone also consume large amounts of energy and has a high environmental cost. The choice of locally available stone building products relieves this problem somewhat while also providing a market for a locally available building material. By this reason only locally available material is really environmentally friendly.

Clay has always been a traditional natural building material for both load-bearing and non-load-bearing wall systems and can be found all over the world.

Bricks and structural clay or roofing tiles are produced by heating clay to a high temperature in kilns, and sand-lime bricks by using steam pressure to heat sand and quick time. These wall materials can not really be regarded as natural. Although they have natural ingredients, a considerable amount of petrochemical energy is required to produce them.

3.3. Energy Efficiency at Home[7]

Energy use in buildings is the most significant factor in terms of impact on the environment. Energy used in buildings could be saved applying energy conservation strategies such as better insulation, replacing windows, sealing air leaks, installing modern and more efficient heating and air conditioning systems and landscaping designed to provide barriers to winter winds and shade during the summer months.

After the oil crisis in 1970s the energy-efficiency in buildings has become one of the most important factors to be considered.

Energy efficiency was promoted in basically three ways:

1. Regulations in the form of energy codes and design standards
2. Certification or labelling programs
3. Tax incentives for investment in energy efficiency technologies

Modern energy efficient building standards developed in the private sector by a number of groups, such as the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) now provide standards for buildings which result in up to 40%

[7] "Energy Efficiency in Household Appliances". Paolo Bertoldi, Andrea Ricci, Boudewijn Huenges Wajer. Springer 1999

less energy use than in buildings constructed prior to the 1970s[8]. Energy consumption can be reduced simply by using increased insulation without any need for expensive and sophisticated technology. Building materials and advanced building technology can be used to construct buildings that consume far less energy and will enhance the resident's quality of life.

Low energy houses may soon be standard practice. They use less energy for heating than the minimum established by local building regulations. A low energy house requires adequate thermal insulation in all the external sections of the building. The heat lost is mainly through the walls, windows and roof. The losses through the roof could be 20% but in new building the losses can be lower and can be reduced taken the convenient measures.

In practice the preference is for a combination of different materials as wood, plastic, stone, insulation material and others. The U-value for each material is important when we have to choose between different options. The lower the U-value, the less are the heat losses of the structural element.

Therefore, in order to attain a specific total U-value the thickness of a particular material would be adjusted according to its heat loss coefficient. It is important to choose materials with high insulation capacity in order to reduce the thickness.

A low energy house usually has thick external walls, windows with expensive high-performance glazing and relative complex and costly construction, but all this is not really necessary because if all the considerations are studied in the plans for a low energy house before building starts it is possible to reduce costs considerably. The most important energy saving measures in construction can be summed as follow:

3.3.1. Energy saving measures[9]

- Provide efficient thermal insulation for all external parts of the buildings
- Avoid heat bridges and other energy leaks

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[8] American Society of Heating Refrigerating and Air-conditioning Engineers. "Energy Efficient Designo f New Low-rise Residencial " ASHRAE 1993

[9] "Energy Efficiency in Household Appliances". Paolo Bertoldi, Andrea Ricci, Boudewijn Huenges Wajer. Springer 1999

- Provide airtight building fabric, avoid heat loss through ventilation
- Provide efficient heating systems with the lowest possible inertia
- Provide adequate thermal mass especially if passive solar energy is utilized

But conventional and ecological builders don't agree in the energy saving measures that have to be taken. The ecological builders think that an efficient insulation only can be achieved with unhealthy synthetic materials, the thick layers of insulation would probably exclude any possible benefit from the warmth generated by solar energy, and that airtight building is neither comfortable, because a building has to breathe. And finally that heating must utilize only renewable materials as wood or solar energy and systems with high level of radiation (tilde stoves, under floor heating, wall surface heating). The correct way to act is to achieve an agreement between the two conceptions to take energy saving measures.

3.3.2. Shapes in buildings

The external structural elements are the greatest contributions to the heat losses and gains as thermal loads of a building. The meaning of this is that the more compact the house, the more energy efficient it will be.

Therefore it is important to make sure that all the available space within the house is well used and necessary for the functional needs of the occupants.

Depending on the shape of the house, the outer shell can be made more compact without sacrificing building volume. A geometrically compact shape such as a half sphere, half cylinder, a cube, has the lowest heat loss because it has a small surface area in relation to volume, (Ex: the igloo is the most efficient building shape in terms of energy consumption).

The lower the relation of external surface area A and the volume V, (A/V) the greater the energy efficiency. With these compact buildings we can get saving space and conserving energy.

3.3.3. The zero-energy houses or passive houses

A passive house heated with solar energy that generates its own electricity with modules or from other renewable in the way that no external energy sources are required is called zero-energy house.

The most highly sophisticated from of low-energy house makes use of passive heating systems. This type of houses often uses less than 15 kWh/m^2 of annual heating energy. The term “passive” is use because the building requires very little heating energy and a smaller active heating system to meet its heating requirements.

This type of houses work using the natural body heat of the occupants and heat emitted by electrical appliances, for example, refrigerators, hot water heater, and computers. It is normal to use a heat recovery ventilation system to recapture and to recirculate warm air and always these houses work by harnessing passive solar energy.

Frequently the value of the heat generated within a building is underestimated. A person reading can release around 100 watts into the space around, a computer can release 150 watts of thermal energy and for example the house hold appliances could release 10 kWh/m^2 of surplus heat per day.

The heat from the sun penetrating the windows of a passive solar house will be reduce by the use of glass with high insulation properties but it is better to use a more standard glass because the sun can contribute toward the total heating requirements in a house with moderately good thermal insulation.

Some of these types of houses are designed to use renewable energy sources such as photovoltaic and wind and to be completely independent of conventional fossil fuel sources. For the zero energy houses is usually used the solar technology to produce domestic hot water and also to generate electricity.

3.4. Technology in the house[10]

The cost of constructions is rising due to the home technologies. This could be due to the necessity of comfort, the obsession for achieving a high level of internal comfort using technologies as the air conditioning which can be not necessary if we think about alternatives or other constructive elements before the construction starts.

It is necessary to think how to adapt the building to the nature, to use the local climate conditions in order to build a house that it works in relation with them. With this it can be possible to compensate the use of energy home technologies such heating and cooling systems.

Reducing technology at home it is possible to minimize effects on human health due to air pollution, electromagnetic field pollution and global warming which accompany many electrical appliances and technological comforts.

It is difficult to combine environmentally friendly methods of buildings with an appropriate use of the technology. But, really, it is necessary the technology at home and the idea is that the technology should be as simple as possible and environmentally sensible with appropriate technologies, such as solar heating and rainwater harvesting systems for example (easy to maintain, easy to apply and don't interfere with other required systems).

The purpose of this point is to show the different technologies applied at home for different uses. Some of them have been explained in previous points and other are going to be treated here, but only the most relevant. When a house ecological and friendly with the environment is going to be built, it is necessary to think about the best choice for the different elements. Therefore, possible elements to consider in these cases could be as follow:

- Heating and warm water
- Ventilation: natural, air conditioning, alternative cooling methods
- Planning for lighting
- Daylight use

[10] Advanced Buildings Technologies and Practices. (http://www.upv.es/bib/recursos/recursos.htm)

- Electromagnetism
- Generation of electricity: photovoltaic, wind power or electric grid
- Water systems
- Waste treatment systems

A general idea about the most important of them for the project is going to be exposed to know how they work and which are their characteristics, the alternatives and to focus the best use of these elements in buildings.

3.4.1. Solar architecture

The goal is to harness the sun in an active and passive way. Passive heating techniques could be easy to achieve and they not include a high technology. Some elements are:

- Direct gain: one side of the building elongated and oriented to the south with large windows or surface glasses.
- Indirect gains: a greenhouse as a glass collector area

Active solar energy includes a much more high technology and an intensive use of it. Some of these technologies are the transparent thermal insulation and thermal and photovoltaic collectors as an electrical power resource.

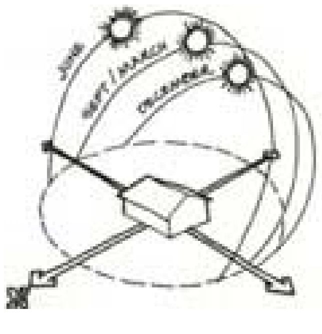


Figure 3.4.1.1: Pasive solar radiation[11]

3.4.2. Heating and water system heating

The process to choose the most environmental heating system and heating fuel depends on the immediate conditions including climate, site characteristics, geography, local

[11] www.azsolarcenter.com/design/ images

ordinances, availability of fuels and materials, building size and type, investments and others.

Wood-fired heating such as wood burning stove or furnace possible combined with a solar heating system of some may be a correct alternative in the countryside for example, where piped natural gas is unavailable and firewood is plentiful. By contrast, the optimum system for an urban single family house is usually gas heating. Combining an energy efficient furnace with a solar energy system is usually the best choice.

In apartment buildings, housing and self sustaining communities could be better to use a centralized heat source as a communal cogeneration plant which simultaneously produces hot water for heating and electrical power instead of using many individual heating systems.

There are several methods for heating and some of them are as follow:
Cogeneration is an efficiency way to produce heat and electrical power. Many modern small power plants produce more than just electricity and the waste heat are reclaimed for heating purposes. This means that almost all of the energy from oil or gas can be effectively utilized. Now cogeneration plants can be as small as an ordinary domestic heating system.

Oil or gas heating and condensing boiler technology are other options and the decision about to heat with oil or gas depends on whether the natural gas is available as a piped supply. If it is possible, the gas heating is the cleanest form of fossil fuel energy in environmental terms.

In modern low temperature systems, oil and gas fired boilers use roughly equal amounts of energy, the levels of pollutants emitted by gas systems are always lower. Oil fired condensing boilers are far more expensive so gas is the best choice.

Many people prefer fuel oil because they think it provides a more reliable supply than energy sources such as gas that rely on pipe networks. Besides, oil is cheaper but using oil as a heating fuel requires expenditures for boiler rooms and tanks which are not needed for gas heating. Modern boilers don't need a boiler room and they can easily be integrated into the living space, bathroom or kitchen.

Heat pumps work in the same way than a refrigerator or air conditioning system because they transfer heat from an area of lower temperature to one of higher temperature. It is possible to reverse the process and provide cooling in addition to heating.

There are basically three types of systems as air to air, water to water and ground to water respectively. The manufacturers claim that heat pumps produce 50% less of greenhouse gas CO_2 than oil or gas fired heating systems. It has been demonstrated that air to air systems used in single and family houses produce about the same CO_2 emissions as conventional oil fired central heating system.

The ecological balance of heat pumps depends not only on the preceding generation of electricity, but on how efficient the system is. In terms of heating energy it is possible to compare heat pumps based on the COP (Coefficient of Performance). This coefficient is the ratio of heat energy produced to the electrical energy input. As an example for air to air system the value of COP is 3.0.

Some times depending on the temperature outside, the heat pumps require the addition of conventional heating and in this case the question is to know if they are economical. The water to water systems can achieve a COP of 4.0 or higher but the high initial investment cost to install them create a very long payback periods and they have a constant maintenance because of the presence of the legionella bacteria due to the water system.

Wood fired heating is a conventional system. Wood was the original heating fuel during years. There have been advances in wood burning over the past five years which have made wood burning more effective, safer, and efficient and they can cause a feeling of internal comfort.

The new wood heating installations are attractive and their advanced technology fireplaces are located in main living areas.

Burning wood can be considered environmentally friendly because wood is a renewable energy resource. Only it is necessary to be carefully with the smoke to avoid its presence in the indoor environment.

Some measures to take could be to select an optimum appliance in size and location to make the most effective use of heat produced, to use a modern chimney, etc.

Other new technologies which have been developed can reduce the amount of smoke and other pollutants produced by wood burning appliances. They are the advanced wood-fired heating systems, tiled stoves and others as for example the surface heating using radiation or convection, the radiant wall heating systems and radiators in general.

- **Solar system for heating water**

Solar water heating systems absorb solar radiation and transfer the heat to storage in the form of water tank. In domestic hot water systems, the energy colleted is then used to heat potable water directly or by a heat exchanger.

The energy savings of a solar system can be predicted on an annual basis, but due to the variations in the climate and sunlight availability, the savings at any time of the day, the month or the year are unpredictable.

Besides saving energy costs other benefits are the increased capacity due to a large storage tank, no pollution and the increased reliability.

The location of the solar collectors is important and the collectors should be rotated the optimum degrees of solar south (30 º). It is important to note that a tilt angle equal to the latitude minus 15º will maximize summer solar gains but reduce winter gains and latitude plus 15º maximizes winter gain and produces a solar energy production more uniform throughout the year. Always it is interesting to reduce the installed cost and improve aesthetics with an optimal orientation.

The domestic solar hot water system works in the way that the heat produced by the solar collectors is fed via a heat transfer fluid (refrigerant) to heat exchangers in a thermal storage tank installed in the house. If the solar energy is not sufficient to heat the hot water in the storage tank to the desired temperature (38-46º C) the water can be heated to that temperature by means a conventional boiler or hot water heater.

The solar heat exchanger is on the bottom of the storage tank and that of the boiler on top. The best position for the storage tank is directly under the roof where they are mounted.

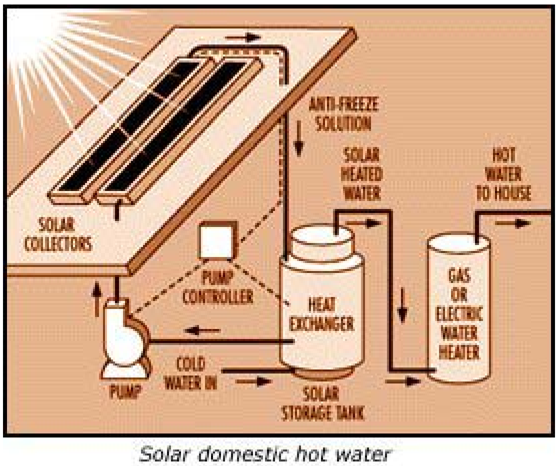


Figure 3.4.2.1: Solar domestic hot water[12]

3.4.3. Ventilation

The use of natural ventilation in buildings is an attractive way to reduce energy usage thereby reducing costs and CO_2 emissions. Generally, it is necessary to remove excess heat from a building and the designer can use the buoyancy forces associated with the above ambient temperatures within the building to drive a flow - 'stack' ventilation. The most efficient mode is displacement ventilation where warm air accumulates near the top of the building and flows out through upper level vents and cooler air flows in at lower levels. Ventilation will also be driven between these lower and upper openings by the wind.

[12] Advanced Buildings Technologies and Practices. (http://www.upv.es/bib/recursos/recursos.htm

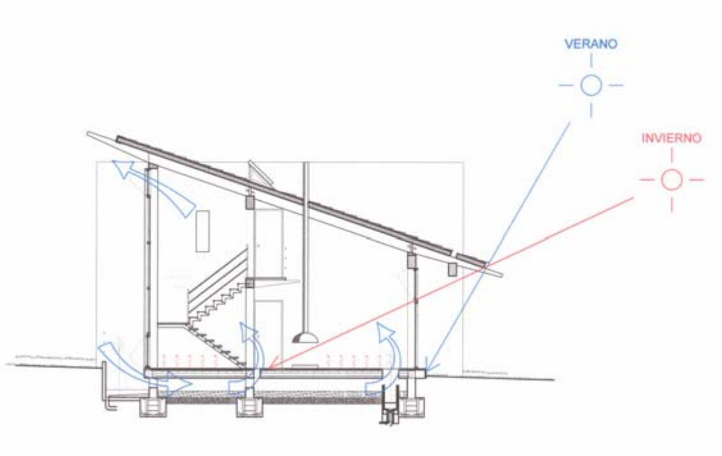


Figure 3.4.3.1: Ventilation system in the bioclimatic house of the case study. Project of the Architect Luis de Garrido

3.4.4. Lighting planning and Daylight use

Lighting should be carefully placed to ensure that crucial working areas and living spaces are adequately lit and to avoid veiling reflections. Some types of lamps are:

- Compact fluorescent lamps
- Energy saving lamps
- Halogens lamps
- Incandescent lamps

It is not preferable to use artificial lighting of low efficiency. It contributes in increased cooling loads demand. The heat produced from artificial lighting adds to the casual gains, increasing indoor temperature.

The use of the daylight is necessary in the built environment. Natural daylight is essential for our well-being. It is necessary not only to see, it also regulate and stimulate our metabolism and hormones.

Daylight is also superior to artificial light in terms of quality. It is necessary to consider the next ideas for the correct use of the daylight:

- Avoid the direct sunlight on critical tasks. This can cause glare and visual disability.
- Permit a good penetration and a good distribution throughout the space
- Filter the daylight using trees, plants, screens, translucent shades, and others.

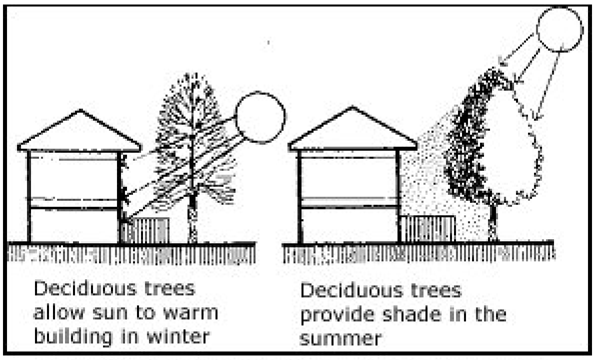


Figure 3.4.4.1: Examples of side landscape features that help to conserve energy[13]

3.4.5. Generating electricity in the built environment[14]

- **Solar energy, PV**

A solid-state semi-conductor device. Light shining on a PV cell liberates electrons which are collected by a wire grid to produce direct current electricity.

The use of solar energy to produce electricity means that PV systems reduce greenhouse gas emissions, electricity costs and resource consumption. Not only is electrical consumption reduced, but because the peak generation of PV-electricity coincides with peak air-conditioning loads, peak electricity demands (from the grid) can be reduced.

PV can also reduce electrical power installation costs where the need for trenching and independent metering can be avoided. The public appeal of using solar energy to produce electricity results in a positive marketing image for PV-powered buildings and thus can enhance occupancy rates in commercial buildings.

While conventional PV design has focused on the use of independent applications in which excess electricity is stored in batteries, grid-connected systems are becoming more common. In these cases, electricity generated in excess of immediate demand is sent to the electrical grid and the PV-powered building receives a utility credit. Grid-connected systems are often integrated into building elements. Increasingly PV cells are

[13] Advanced Buildings Technologies and Practices
[14] Advanced Buildings Technologies and Practices

being incorporated into sunshades on buildings for a doubly effective reduction in cooling and electricity loads.

PV power is being applied in innovative ways. Typical economically-viable commercial installations include parking lot, pathway, or sign lighting, emergency telephones and small outbuildings.

A typical PV module consists of 33 to 40 cells and is the basic block used in commercial applications. Typical components of a module are aluminum, glass, tedlar and rubber; the cell is usually silicon with trace amounts of boron and phosphorus.

Because PV systems are made from a few, relatively simple components and materials, the maintenance costs of PV systems are low. Manufacturers now provide 20-year warranties for PV cells.

Photovoltaic systems are adaptable, and can easily be removed and re-installed in other applications. Systems can also be enlarged for greater capacity through the addition of more PV modules

- **Wind energy**

Wind energy systems generate electrical energy by harnessing the power in wind using machines called wind turbines. Wind energy can in stand-alone applications or can be produced centrally and distributed to the electric gris.

Windplants or wind turbines are available in a variety of configurations with various outputs. Typically, these plants produce either direct current (DC) or alternating current (AC) electricity. DC windplants are used to charge batteries or produce heat/electricity without storage. AC windplants are used to produce electricity for direct use or to supply energy to a utility grid. Water-pumping wind energy systems are another type of wind energy application; these use wind to produce mechanical energy to pump water, typically for agricultural applications.

There are several different systems used. Some wind plants have a vertical axis wind turbines (VAWT) and others have a horizontal axis (HAWT). HAWTs are most common; VAWTs may look something like an eggbeater. Various windplant designs use gearboxes, belts or direct drives. Some have rotor blades which change pitch to reduce loads and speed in high winds. Others have fixed pitch blades. Some HAWT designs face upwind and have tails, others face downwind with no tails.

The most important benefits are that it generates electricity from renewable energy, it does not generate air emissions or pollution and it eliminates fuel supply problems. On the other hand, the wind energy is limited to windy locations.

3.4.6. Water systems

Rainwater harvesting system. An above or below ground storage system that collects, stores and distributes run-off of rain or snow from roofs.

A rainwater harvesting system is composed of a water-collection system, a storage cistern and a water distribution system. Cisterns should be water tight with smooth interior surfaces. Manholes or other covers should be tight to prevent the entrance of light, dust, surface water, insects and animals. Manhole openings should have locks to minimize the danger of contamination and accidents. Inlet, outlet and wastewater pipes should be effectively screened. Cisterns and wastewater or sewer lines should not be connected. Underground cisterns are best built with reinforced concrete.

Rainwater begins as distilled water but collects pollutants from the air and from the roof surfaces. A simple metal screen can filter the water effectively for landscape irrigation, however more complex purification systems are needed when collected water is used for other purposes.

A small pump and pressure tank can be used to provide a distribution system that will allow extraction of the collected water.

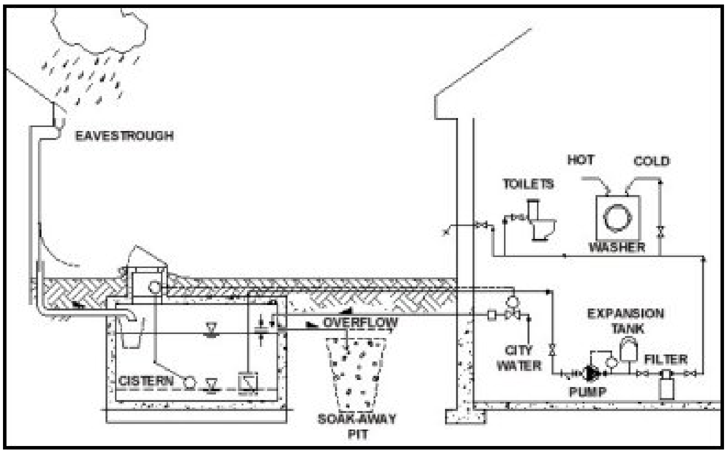


Figure 3.4.6.1: Rainwater harvesting system

Grey water. The collection, storage, treatment and redistribution of laundry and bathing effluent for toilet flushing, irrigation, janitorial cleaning, cooling and laundry washing.

Water conservation technologies are being developed to reduce the cost of municipal infrastructure and to increase opportunities for development. In addition, limited water supplies may be insufficient for population requirements. The use of greywater may increase capacity for population growth or development without the need for additional water resources.

Typically, water conservation techniques are applied in order to reduce the consumption of water for individual applications, such as bathing or toilet flushing. The alternative of recycling recognizes that wastewater and the entrained nutrients are recoverable resources, and that whole-system life-cycle costs may be reduced by appropriate water management techniques on a small scale.

In a recycling system, wastewater is collected, treated, stored and re-distributed for appropriate uses within the house or community. The amount of fresh make-up water required depends on normal losses, such as evaporation and spillage, and the break-even point between fresh-water supply costs and in-house treatment costs. The level of treatment (and associated costs) is determined by the intended utilization of the recycled water, such as irrigation, laundry, bathing, cooking or direct consumption. To the extent that the water can be recycled multiple times for various purposes, the net water demand can be reduced towards zero. Hence, municipal infrastructure costs can be reduced and a secure supply of safe water can be ensured in otherwise difficult-to-service regions

4. METHODOLOGY FOR THE SUSTAINABLE DEVELOPMENT

4.1. Introduction and proposal

The proposal of a strategy for sustainable development in the construction sector is going to be explained and analysed in this point. The main idea is to propose an idea about a good strategy to be followed for the construction of bioclimatic and ecological houses in relation with the sustainable development.

The global strategy proposed has to permit an integral architecture, perfectly integrated with the environment. The most important thing is to build easy and flexible buildings which could satisfy our necessities during the life.

The basic goals for this proposal are:

1. Design Excellence
2. Sustainable construction Excellence
3. Healthy and human well being Excellence
4. Technological Excellence

For future building constructions exit a number of influences which are based in general and important actual aspects. These influences are as follow:

1. Social and economic influences
2. Ecological influences
3. Technologic influences
4. Health influences
5. Design excellence

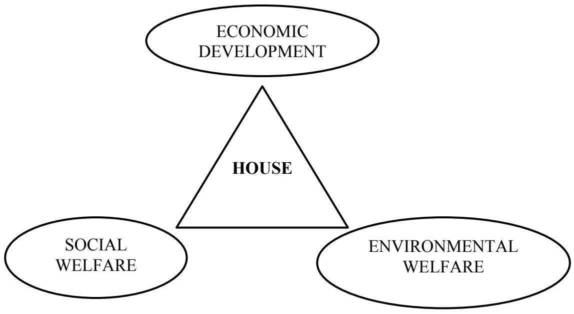


Figure 4.1.1: Interrelation of different influences[15]

[15] "Sustainable Urban Design. An environmental approach". Edited by Randall Thomas, 2003

To formulate a sustainable development strategy is important to start thinking about the best way or methodology to act. The previous steps to carry out could be:

1. Establish the desired way of life and the local needs of the inhabitants
2. Identify sustainable indicators to have an objective way to work
3. Establish and execute actuation policies
4. Evaluate and modify actuation policies with sustainable indicators if it is necessary

METHODOLOGY FOR SUSTAINABLE DEVELOPMENT IN BULDING DESIGN

4.2. Sustainable Indicators[16]

4.2.1. Introduction[17]

The World Watch Institute has developed a group of universal indicators. Other countries have done the same in a national or local level. They have understood that with the "indicators" for the sustainable development it is possible to know the real situation of development for a country, region or community, and after that it is possible to design considering these data taking preventive measures and quantifying the effect of each indicator. It is really a strategy to achieve the desired objectives.

An example of how to identify these indicators is to show the indicators adopted for the Holland Government, all of them referred to the environment (environmental indicators)

[16] Worldwacht Institute bibliography and Luis de Garrido strategy for sustainable development in the built environment.
[17] United Nations. Indicators of Sustainable Development

Holland Government Indicators

1. Climatic change	• CO_2 Emissions • CH_4 Emissions • N_2O Emissions • Production and use of CFC
2. Exhaustion of the ozone layer	• CFC's Production • Halogens production
3. Environment acidification	• SO_2 Fallout • NOx Fallout • NH_3 Fallout
4. Environment eutrofizacion	• Phosphorus • Nitrogen
5. Toxic substances dispersion	• Agricultural pesticides • Other pesticides • First order pollutant agents • Radioactive substances
6. Solid waste disposition	• Total of solid waste
7. Local environment perturbation	• % of citizens affected by noise, bad odours

We can use this kind of indicators in construction, but they are general indicators and it is necessary to specify in depth other aspects to evaluate completely and to know the type of construction in every moment, the global impact in the environment, economic, social and cultural impact.

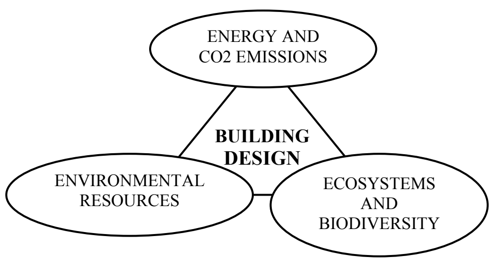


Figure 4.2.1: Relation of different groups of indicators[18]

[18] "Sustainable Urban Design. An environmental approach". Edited by Randall Thomas, 2003

Nowadays, some constructions follow environmental criteria in the design. The solar energy use, energy efficiency, insulation measures, but only they are concrete actions. A global and general reference in an elaborated strategy doesn't exist to achieve a sustainable architecture.

By this reason it is important to define basic parameters and to create a group of useful indicators to define the sustainable degree or sustainability of a construction. With this it is possible to know if a building or a house are ecological and in which degree. The indicators must be significant, representative and to have an easy interpretation.

To define the sustainable development it is necessary to know the sustainable indicators because in this way, the definition is easier to formulate. Without the indicators in construction it is impossible to define with precision the sustainable architecture.

Theoretically it can defined the sustainable architecture as the architecture which permit the construction of buildings in an integrated way with the nature, with a narrow relation, to guarantee the satisfaction of our necessities and without to compromise the future generations.

It is the same to think about which concrete measures have to be taken? Which materials are more ecologic for constructions? Which paint can be used? Which type of architecture is better depending on the place? And in general, which kind of building is ecological and which not?

With the indicators, architects and engineers could know the measures to be taken in the construction to achieve a good degree of sustainability in their buildings. It gives to the surrounding a high comfort and it is friendly with the environment and with our health.

To define the indicators we can't forget any important aspect for the constructions because the other aspect like environmental and ecological, are more general. The use of the proposal indicators is really easy.

For this strategy 33 indicators in 5 groups have been established. Each indicator can be quantifying separately with a percentage or proportion. With this it is possible to obtain a decimal value from 1 to 10 and after that it is possible to get the arithmetic average to give a medium value to the indicator's group. It will be obtained one value for each group showing the total degree of sustainability for a selected construction.

4.2.2. Ecological indicators for a sustainable construction[19]

Next, it is exposed the detailed list within the proposal sustainable indicators. These indicators are general but it is possible to adapt and modify depending on the time and the place conditions where they are going to be applied.

The groups are:

1. Materials and Resources (MR)
2. Energy (E)
3. Waste management (WM)
4. Health (H)
5. Use (U)

It is possible to define and study each one of these factors to give an idea about what is for us the sustainability in buildings. Every factor must be considered if we don't want to forget anything in the correct definition of sustainability, talking about ecological and bioclimatic buildings. Next the factors are defined and classified in the different groups.

1. Materials and resources

- 1.1 Degree of natural resource utilization
- 1.2 Degree of recycled resources utilization
- 1.3 Degree of recyclable resources utilization
- 1.4 Degree of durable resources utilization
- 1.5 Recycled capacity of used materials and resources
- 1.6 Reusing capacity of used materials and resources
- 1.7 Reusing capacity of other materials with different functions
- 1.8 Degree of renovation and reparation of used resources

[19] The complete chapter is based on the Architecture for sustainable development of Luis de Garrido and the references of chapter 6.

2. Energy

2.1 Energy consumption in building materials obtention

2.2 Energy consumption in building process

2.3 Suitability of technology respect human parameters

2.4 Energy waste of buildings

2.5 Thermal inertia of building

2.6 Construction process efficiency (time, resources and labour)

2.7 Energy consumption in materials transport

2.8 Energy consumption in workers transport

2.9 Degree of passive use of renewable energies utilization (by building design)

2.10 Degree of active use of renewable energies utilization (by technologies devices)

3. Waste management

3.1 Degree of generated waste in buildings materials obtention

3.2 Degree of generated waste in building process

3.3 Degree of generated waste using the building

3.4 Degree of alternative use of building waste

4. Health

4.1 Toxic emissions to the environment (Particles, Electromagnetism, Noise,)

4.2 Toxic emissions for human health (Particles, Electromagnetism, Noise,)

4.3 Degree of illness and discomfort of building users. Internal comfort

4.4 Degree of satisfaction of building users

5. Use

5.1. Energy consumption (when building is occupied)

5.2. Energy consumption (when building is not occupied)

5.3. Resources consumption due to building activity

5.4. Emissions due to human activities into the building

5.5. Energy consumption in building access

5.6. Degree of building environment integration

With a defined strategy and using these indicators could be possible to know if the design process followed provides a 100 % sustainable building construction.

In every bioclimatic construction could be useful to consider the next actuations in each step or different activities during the **design process** (taking in account the defined indicator for the strategy proposed)

1. Project activity: based on ecological and bioclimatic conception with a new and innovative perfect design and to achieve the optimum structure to get a low energy consumption building.

2. Site criteria

- In function of the meteorological phenomena
- N-S position or direction to get a natural ventilation
- Optimum access to the location to decrease the energy consumption and make easy the transport of materials, the communications with other places, to reduce the environmental impact on the land.

3. Construction process:

- An efficient construction process to decrease building costs and build in the way to reduce the time of construction
- Construction process as much easier as possible
- Promote the use of renewable energies during the construction process
- Try don't have waste and residue during and after the construction. Use every thing that it is possible
- Eliminate destructive actions during the construction process.

4. Building

- Local workers
- Optimum constructive system with only the necessary elements
- Use of sustainable materials which have been obtained with a low energy consumption and a low generation of waste
- Decrease the transport of materials as much as possible
- Reuse recover and recycle of materials

5. Constructive solutions

- Force the N-S position or direction to permit a solar control
- Maximise the high efficiency of the building
- Use alternative energies
- Increase the insulation of buildings
- Increase thermal inertia of the building
- Permit a natural ventilation thermically efficient
- To achieve a natural thermal conditioning
- To obtain a flexible building according with the changing climate conditions

6. Equipment

- Domotic control system
- High energy efficiency in lighting
- High energy efficiency in heating systems
- Technology and house hold appliances of high energy efficiency

7. Use

- Change in resident customs
- Promote the new technology of more efficient equipments
- Minimize the waste generation
- Promote the reuse of waste and residuals

8. Reuse, recover and recycle of the own building

- Design thinking about the possible future recycling of the building
- Reuse every material used during the construction to do something
- Don't generate debris and use in the own construction
- Use materials of demolitions
- Use materials of other activities which don't have any applications. An example could be the old tyres.

4.3. Sustainable Architecture Design Strategies

It is possible to define six different strategies to follow when a sustainable construction is projected. The proposed strategies are based in some of the sustainable indicators defined before and are as follow:

1. Design to endure
2. Design to repair
3. Design to reuse and regenerate
4. Design to biodegrade
5. Design to reduce resources and residues
6. Design to recycle

4.4. Inverted Pyramids Theory

When a sustainable and bioclimatic project is achieved it is necessary to be realistic and don't think that applying the high technology and with expensive new materials or for example PV for solar energy we could have a better project. It means that it is important to create and project with only the necessary elements.

There are a lot of possibilities for a bioclimatic projects and one important factor is the cost. Not every project would follow the same sustainable actions because each one would have a different budget. It is necessary to adjust the work with the price or cost of the project.

By this reason and depending on the project, it is possible to start using simple and easy techniques with low costs and follow with other more expensive actions whether for project is required and possible.

The next diagram shows the inverted pyramids theory. This theory is really simple and it is easy to understand the meaning of the proposed strategy to carry out a sustainable construction following the idea of this theory. We could save costs and make the maximum with the minimum in a completely bioclimatic construction.

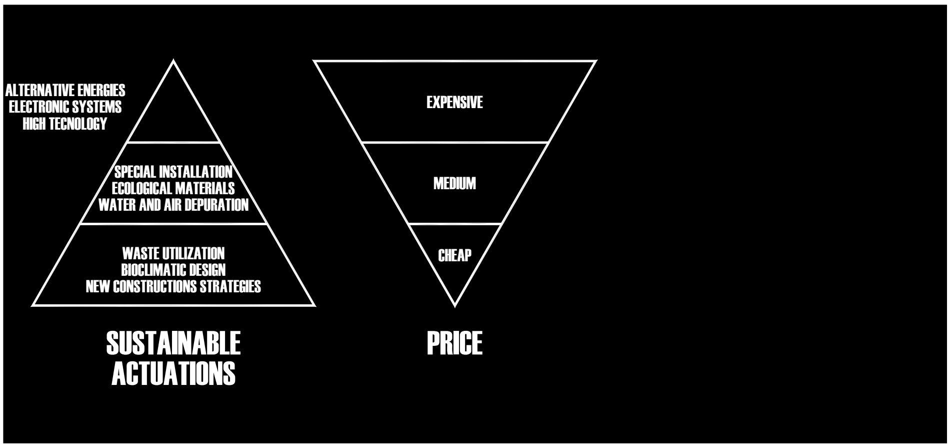


Figure 4.4.1: The inverted pyramids theory.

4.5. Usual Sustainable Actions[20]

In the inverted pyramids different sustainable actions have been proposed in function of their costs and more difficult technology or infrastructures. The main thought could be "Do the maximum with the minimum" and "less is more", and it is really useful to innovate and create new techniques and to decrease costs of constructions.

With all the last information, in this point, the most important and usual sustainable actions have been defined and classified depending on the additional cost that they present.

No additional cost

N-S orientation
Eco-urbanism
Architectural typology
Reorganize spaces
Cross ventilation
Reorganize windows
Solar protection
Recovered materials
Waste utilization
Thermal storage systems
Bioclimatic design

[20] Sustainable actions defined by Luis de Garrido Stratategy

Landscape cover

Factory manufacture

Improve planning

No waste generation

Local handwork

Local resources

Design excellence

Facilities management

Natural convective ventilation

Medium additional cost

Increase Thermal Insulation

Thermal Inertia

Health materials

Ecologic materials

Durable materials

Water rain recovery

Thermal sun energy

Wind collectors

Biomass Energy

Natural ventilation system

Glass improvement

Recycled materials

Recyclable materials

Low consumption technologies

Considerable additional cost

Domotic System

Photovoltaic System

Wind System

High Technologies

Radiant Soils

Ecologic HVAC Systems

5. SUSTAINABLE AND BIOCLIMATIC HOUSES IN THE MEDITERRANEAN AREA

5.0. Introduction

Mediterranean regions have a specific culture and a well defined architectural expression which have been developed during the centuries, when the building tradition had shown a natural capability in adapting to the peculiar environmental conditions.

Common factors can be shown in the different Mediterranean regions which could be considered as technological solutions for providing summer comfort (thermal inertia of the masonries of the buildings, orientation, the ventilation chimney, external surfaces colouring, water storage systems, use of natural lighting, use of renewable).

In these regions the employment of bioclimatic technologies for providing comfort conditions has been lately reducing during the modern building procedures. But the energy crisis in the 1970s and the need to reduce the energy consumption and a better design of buildings have been the consequences to employ of the previous techniques and technologies in the Mediterranean constructions, as the bioclimatic architecture.

After that innovative principles of bioclimatic methodologies are concerned and they could be identified with a design approach which would allow a better balance achievement between comfort requirement and energy sources employment, through a number of solutions compatible with the environmental necessities and protection needs.

Possible countries in the Mediterranean Sea to show and compare the bioclimatic constructions could be Italy, Greece, France and Spain. It could be possible to carry an study of these regions characterised by different dimensions, economy and history, and with a specific survey methodology, to identify the regional situation in the field which will appear appropriate to local reality.

The different realities in each region are important in the selection of the methodology of investigation and study for the research required. It could be good to carry out questionnaires to professionals and people of the sector, to meet with architects, engineers and citizens to compared ideas for the bioclimatic constructions, to get information and to talk with experts.

For this project we are going to analyse the possibility of bioclimatic houses in Spain, in the Mediterranean Coast, an example of bioclimatic constructions in Catalonia and Valencia regions is going to be analyse and to show if it is feasible and suitable for a good sustainable development of the region friendly with the environment, the community and economically positive.

Possible cases or examples to apply the sustainability (sustainable criteria) in buildings could be in single houses, housing, offices, hotels, public buildings, intelligent buildings, etc.

Our case study is based on a sustaining house, single family house, in Spain, where we are going to analyse a bioclimatic single house located in Valencia. In this area there is a Mediterranean climate and in general, warm weather conditions.

The objective is to show if it is possible to build an ecological house based on the sustainable development and ecologically friendly with the environment, the habitat and the human health in this location besides to get a good cost of construction.

Another important point in this project is to study and to show if people, the population, the citizens have enough information about these bioclimatic constructions, the ecological houses. In other words, if there is a connexion between the development in this sector and the people who live in these regions. It is important to show if the inhabitants know the place where they are living and they are happy with it. To carry out this part, the proposal is to prepare a questionnaire for professionals and residents.

Firstly, we are going to analyse our bioclimatic house located in Valencia and to show the main characteristics and secondly to explain the situation of this type of construction related with the sustainable development (sustaining houses) in this region, showing if we know our environment, our surroundings.

PART 1

THE SUSTAINABLE, ECOLOGICAL, BIOCLIMATIC, AND WITH HIGH ENERGY EFFICIENCY HOUSE IN VALENCIA, IN SPAIN.

Before to start with the analysis of the single house, it is necessary to explain the context, to introduce some information about the location, the climate and every important bioclimatic element to give complete information of this project.

5.1. LOCATION

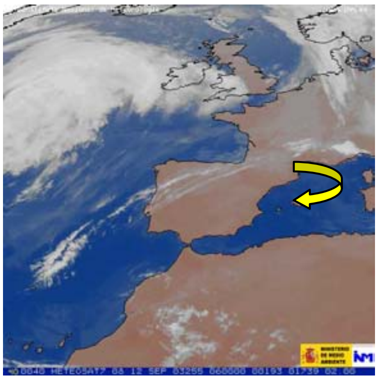


Figure 5.1.1[21]: The Mediterranean Area where is the bioclimatic house.

Figure 5.1.2[22]: The Valencian Community.

[21] National Meteorological Institute. Web: www.inm.es
[22] National Meteorological Institute. Web: www.inm.es

5.1.1. Information of Valencian Community.

Valencian Community is an Autonomous Region with a population of 4 million more or less and former kingdom, East coast of Spain, on the Mediterranean Sea. It now comprises the provinces of Alicante, Castellón, and Valencia. Valencia is located in the South of Catalonia (in the Mediterranean Sea with Barcelona as capital). It was established as an autonomous region in 1982 by the statute of autonomy. The country is chiefly mountainous, with a fertile coastal plain, on which most of the population is concentrated.

The Mediterranean climate has helped to make Valencia the "garden of Spain." Irrigation and an intensive system of cultivation were started by the Moors in the past. Citrus (oranges) and other fruits, rice, vegetables, cereals, olive oil, and wine are now produced. Many of these products (especially Valencia oranges) are exported. The mulberry tree has been cultivated for silk since ancient times, but the silk industry has declined. Processed foods, ceramics, metal products, furniture, and textiles are the chief manufactures. Tourism, especially to coastal resorts, has become more important.

Valencia City has a population of 1.5 million more or less, capital of Valencia province on the Turia River. The third largest city in Spain, it lies in a fertile garden region a short distance from its busy Mediterranean port, El Grao, on the Gulf of Valencia. It is an active industrial and commercial centre producing textiles, metal products, chemicals, automobiles, furniture, toys, and azulejos (tiles of different colours). There also are important shipyards.

5.2. Energy Data in the Valencian Community

To give an idea about the energy policy followed by the Valencian Community it is possible to show the most important data using graphs, diagrams and tables and in this way to know the data related with the energy consumption and the energy efficiency in the different activities and in the different sectors, in detail for the domestic sector.

We have taken the data for the 2001 year because these data are available from the Valencian Energy Agency (AVEN)[23] and it is possible to use them as a guide to estimate the progress in the next years.

- **Basic Data**

- Primary Energy Consumption in 2001: 10800 ktep (kton equivalents of oil)
- Final Energy Demand in 2001: 8451 ktep (in part due to the industry and transport sectors)
- Percent of renewable in Valencia: 3% (goal of 12% in the 2010)

Primary Energy Demand	Thousand of ton equivalents of oil	%
Oil	4858	45
Carbon	1	0
Natural Gas	2645	25
Uranium	2238	21
Hydro	33	0
Electric energy	818	8
Other renewable	207	2
Total	10800	100

Table 5.2.1: Summary of the Energy Balance[24]:

Imports:

- Electricity imports: 8%
- Nuclear: 21 %
- Natural gas: 25 %
- Oil: 45%

Almost the complete demand of energy is imported. Only it is possible to say that our own production is based on the renewable with an important solar plan and the use of

[23] AVEN: Valencian Energy Agency, C/Colon 1, 46004 Valencia. Web: www.aven.es
[24] The reference for every table is the AVEN. All data have been obtained from the Valencian Energy Agency. www.aven.es

solar and biomass alternatives. Hydro is really important in the community but depend on the year (in function of the rainfalls).

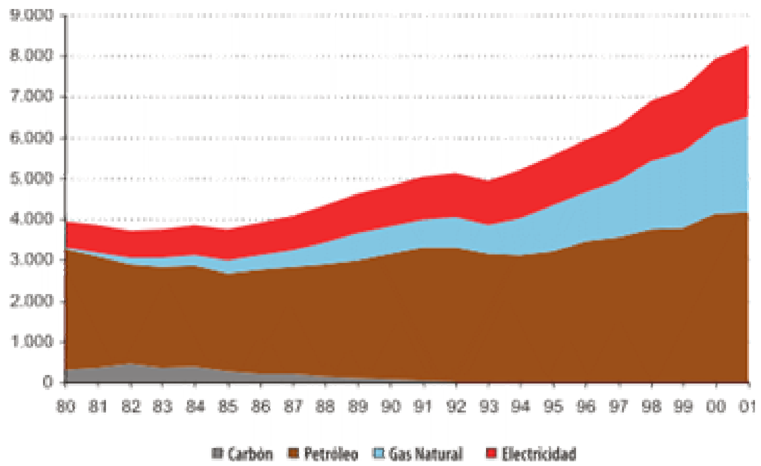
Hydro	33
Other renewable	207
Total	240
Percent	2.2%

Table 5.2.2: Production, (data for 2001)

	Thousands of ton equivalents of oil	**%**
Carbon	1	0
Products from oil	4160	49
Natural Gas	2331	28
Electricity	1764	21
Other renewable	196	2
Total	8451	100

Table 5.2.3: Final Energy Demand

In the next graph it is possible to see the evolution for the Final Energy Demand for each energy source during the last two decades:



Carbon Oil Natural Gas Electricity

Figure 5.2.1: Final Energy Demand Evolution

Evolution for the Final Consumption of electrical energy[25]

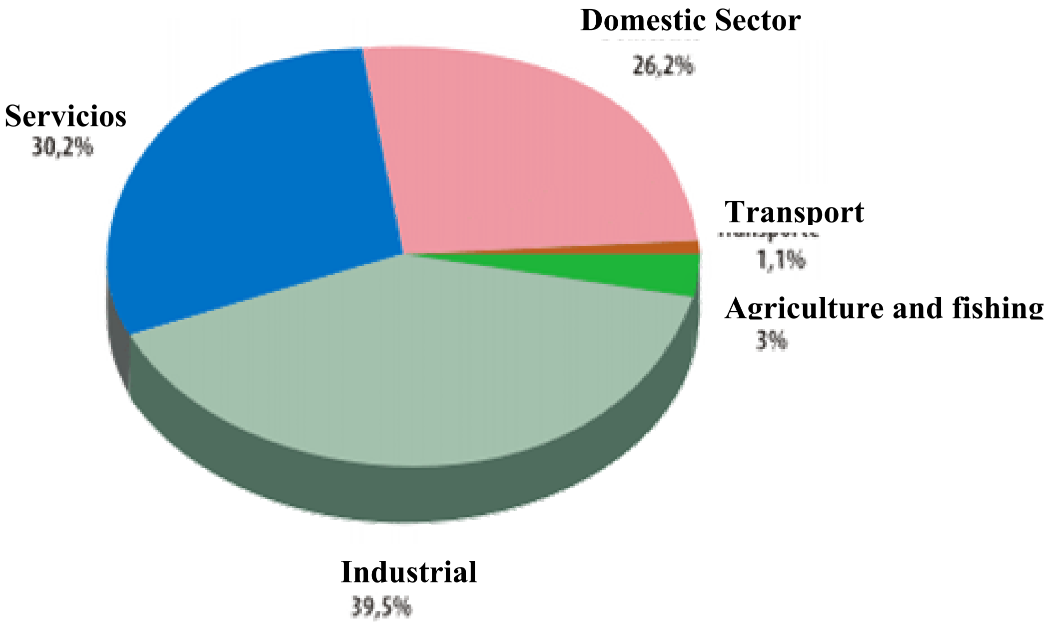


Figure 5.2.2: Evolution for the Final Consumption of electrical energy

- **Economic Sectors**

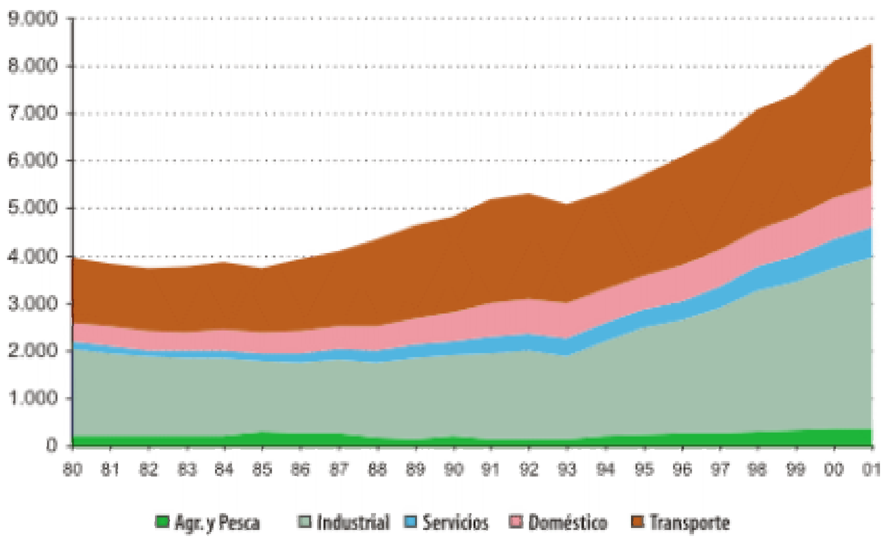


Figure 5.2.3: Evolution of the Energy Demand for each sector

[25] AVEN, Valencian Energy Agency: referente for every figure and every table. In general for every energy data.

Final consumption for the Domestic Sector

(Thousands of ton eq of oil)

Year	80	85	90	91	92	93	94	95	96	97	98	99	00	01	01/00	%
Carbon	0	0	2	1	1	1	1	0	0	0	0	0	0	0		
Oil	223	203	253	280	286	292	275	281	296	289	294	297	282	272	-4%	31%
Natural gas	0	11	28	29	30	32	30	31	35	37	43	48	59	66	12%	8%
Electricity	186	224	305	328	336	341	343	342	360	369	380	415	437	462	6%	53%
Renewable	/	/	/	71	71	71	71	71	71	72	72	72	73	74	1%	8%
Total	409	438	587	709	724	738	720	726	762	768	789	832	851	874	3%	100%
%of total	10%	12%	12%	14%	14%	14%	14%	13%	12%	11%	11%	10%	10%			

- **Environmental and Social factors**

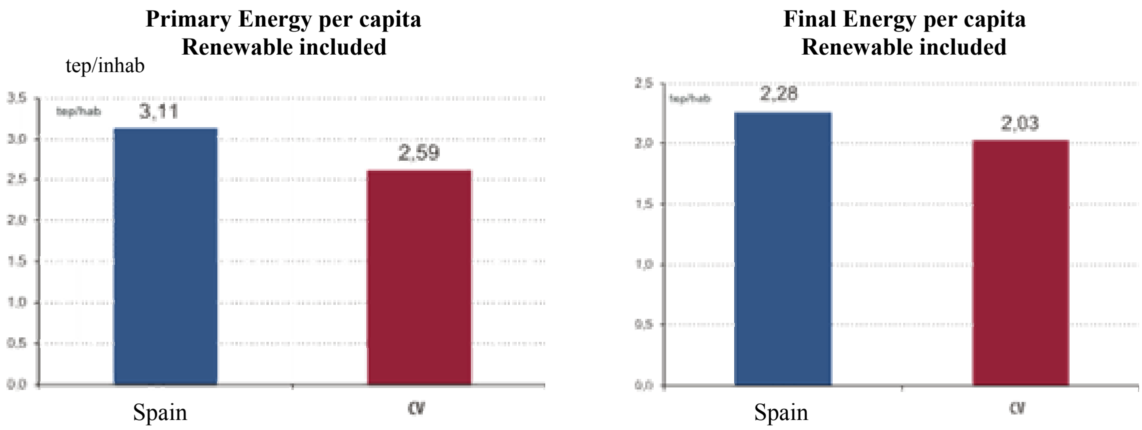


Figure 5.2.4: Energy consumption per capita

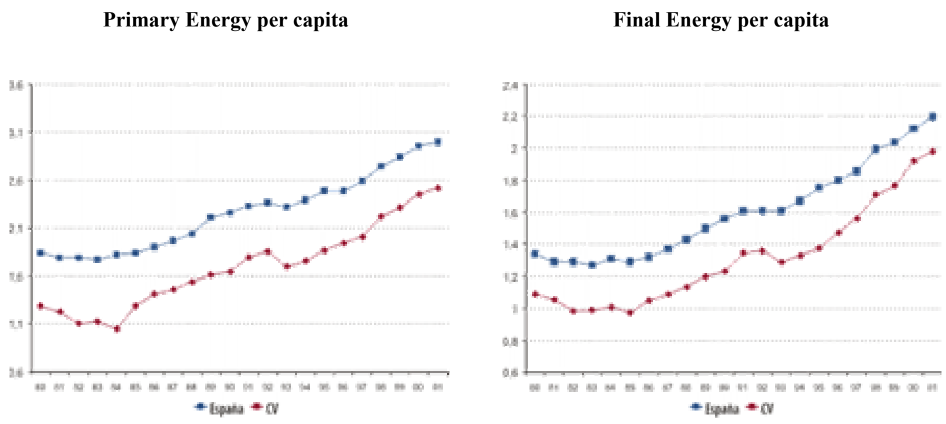


Figure 5.2.5: Evolution of energy consumption per capita

Comparison of CO_2 emissions between Spain and the Valencian Community:

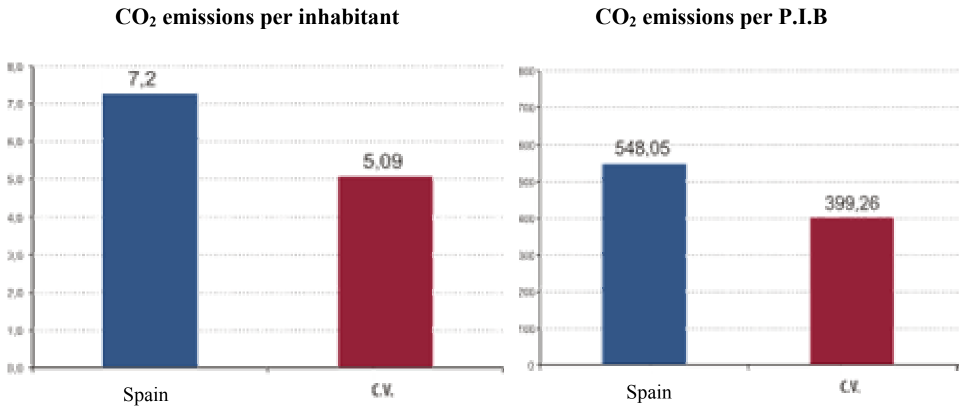


Figure 5.2.6: CO_2 emissions comparison

Primary Energy (Kton equivalents of oil)

	Spain	Valencia (CV)	% (CV/Spain)
Carbon	19528	1	0.0 %
Products from oil	66721	4858	7.3 %
Natural Gas	16405	2646	16.1 %
Total	102654	7505	7.3 %

CO2 Emissions (kton)

	Spain	Valencia (CV)	% (CV/Spain)
Carbon	75590	3	0.0 %
Products from oil	183363	14978	8.3 %
Natural Gas	38338	6184	16.1 %
Total	297292	21165	7 %

5.3 Climate and meteorological data in the area, Valencian Community

In carrying out a bioclimatic project it is really important to consider the climate of the area because the relation between a bioclimatic constructions and the climate of the place is a close relationship. They are dependent because we are constructing depending of the environmental conditions to get the maximum efficiency in every aspect. We are looking for the optimum high quality construction considering the characteristics of the place in the same way that we are working with the resources of the place, talking about ecologic materials, products, local workers and other factors as we have seen before.

Valencia has a warm, Mediterranean climate with good temperatures during the year. As in other bioclimatic project we need to know the weather conditions and build in function of them to achieve the optimum internal comfort in our buildings to provide an optimum quality of life. In Valencia is possible to achieve temperatures of 35 ºC and more during the summer and in constrast, to achieve 10 ºC or less in winter.

For the biclimatic house project, located in the Mediterranean area at 20 km from the coast through the interior lands, the climate data have been analysed and used to know the necessity for our construction to get an optimum internal comfort along the year, and relating the data with the selection of important element in the building as the materials, type of insulation, and others.

The Climate data used for the project have been obtained from the Meteorological Centre of Valencia (Meteorological National Institute).

The given data have been taken during the last ten years, from January of 1995 to June of 2003 and are as follow:

5.3.1. Temperatures[26]

We are going to take the average of the data during the last ten years to give an idea of the climate conditions in the area.

Location: Valencia
Longitude: 00-37-17 W
Latitude: 39-23-40
Altitude: 203

[26] Meteorological Centre of Valencia (Meteorological National Institute). C/ Botánico Cavanilles, 3 46071-Valencia. Web: http://www.inm.es/wcmt/vale/por.html

Table 5.3.1.1: Temperature data table: (Monthly average ºC)

year	Jan	Feb	March	Ap	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1995	10.8	12.4	11.8	13.6	17.6	20.2	23.9	24	20	18.3	14.9	12.4
1996	11.6	9.8	11.6	13.9	16.8	21.6	23.2	24	20.1	17.2	/	10.6
1997	9.2	12	12.6	14.4	17.6	21.8	22.2	24.3	/	19.9	14	11.1
1998	10.2	10.7	12.8	14.8	16.6	21.4	24.6	24.7	22.4	17.3	13.1	9.4
1999	9.8	10.1	11.8	15.8	19.5	22	24.6	26.2	22.8	17.4	11	10.4
2000	7.5	13	12.8	15	19.2	21.8	24.3	24.4	21.6	17.2	12.5	11.4
2001	11	10.6	16	15	17.4	21.6	23.2	24.6	21	18.8	10.9	8.6
2002	10.2	11.6	134	14.8	16.9	21.5	23.8	23.3	21.6	17.4	14.2	12.1
2003	9.8	8.6	11.4	14.2	17.3	/	/	/	/	/	/	/
Average	10.01	10.97	12.68	14.61	17.65	21.48	23.73	24.44	21.36	17.94	12.94	10.75

5.3.2 Rainfall data[27]

Table 5.3.2.1: Data of total monthly rainfall (mm)

Year	Jan	Feb	March	Ap	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1995	0	9	6.5	7.5	8	32	0	67	18.5	32.5	38.5	162
1996	90.5	28.5	16	16.5	47	5	0	2	97	8	/	94.5
1997	89.5	4	6.5	102.5	46	15.5	6	23	143.5	4.5	10.5	38
1998	182.5	41	2.5	6.5	81.5	16.5	0	2.5	11	0	14	119
1999	30	7	76	18.5	14	16.5	17.5	1	79.5	51	18.5	10.5
2000	29	0	27.5	18	25	12	0	8	0.5	39.7	0	25.5
2001	58.5	46.5	10	89.5	61.5	/	0	0	82.5	47	54	98.5
2002	88	0	35.5	88.5	154	/	41	55.5	51.5	49	22.5	42.5
2003	13.5	81.5	32	69.5	91	/	/	/	/	/	/	/

[27] Meteorological Centre of Valencia (Meteorological National Institute). C/ Botánico Cavanilles, 3 46071-Valencia. Web: http://www.inm.es/wcmt/vale/por.html

5.3.3. Relative humidity (monthly average %)[28]

Table 5.3.3.1: Data of relative humidity.

Year	Jan	Feb	March	April	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1995	58	60	58	61	60	64	62	71	62	73	65	70	**64**
1996	70	57	64	63	56	54	57	63	63	65	67	74	**63**
1997	80	70	65	68	64	63	64	69	75	62	65	65	**68**
1998	72	78	65	50	66	65	61	62	62	60	62	69	**64**
1999	64	54	61	52	58	63	66	68	63	71	64	64	**62**
2000	74	66	63	53	64	60	64	66	62	66	60	63	**63**
2001	62	65	56	55	61	65	68	68	69	70	64	70	**64**
2002	72	57	65	65	63	54	60	68	66	64	58	64	**63**
2003	51	66	69	60	62	57	59	/	/	/	/	/	**/**

5.3.4 The Compass (winds) [29]

For wind the given data are for a year with values for each kind of wind during each month but we expose here the average for the year without to specify for each month.

%: % of times that the wind has blown in each direction
V: average velocity in km/hour

Table 5.3.4.1: Average values for a year (winds)

	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NN	calm
%	2	2	4	7	17	7	7	3	2	1	3	7	15	7	7	5	5
V	10	9	12	13	12	12	11	11	9	9	15	18	18	11	10	10	

The given data are from the area where the bioclimatic house is located. They are not the data from Valencia city centre. It was necessary to specify the data for this area because they can vary because Valencia City is located on the coast, with a altitude of 50 m and the house is 20 km form Valencia in the west direction. By this reason the temperature and humidity data are higher from Valencia City than for our area due to

[28] as 7
[29] as 7

the proximity of the sea shore and the pollution, traffic jam, population density and other factors.

5.4. Solar Energy Data of the Valencian Community

To carry out a bioclimatic project based on the use of energy from the sun it is necessary to know the level of radiation which it is possible to get during the year. For this project the solar radiation in the location has to be known to establish the performance of the solar collectors.

The solar energy data showing the solar radiation maps and the solar radiation tables for Valencia is presented below. These data have been obtained from the Valencian Energy Agency[30].

5.4.1 Solar Radiation Maps (monthly data along the year)

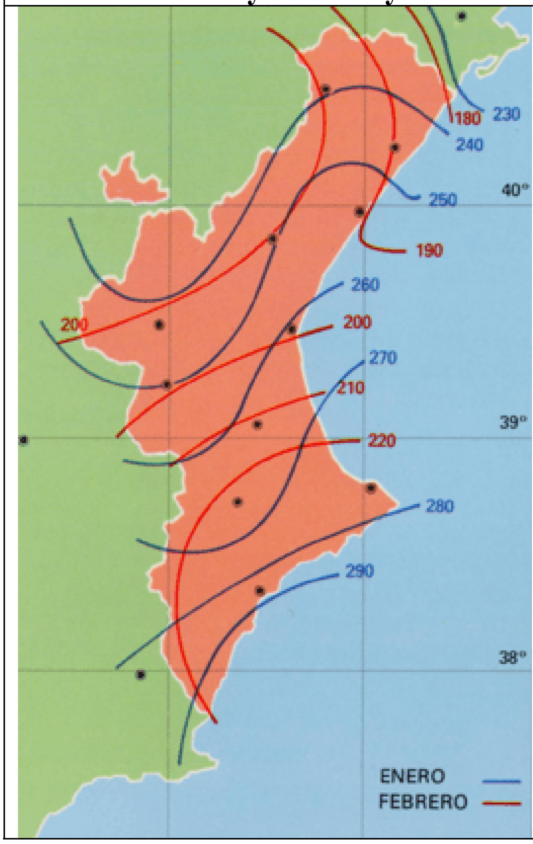
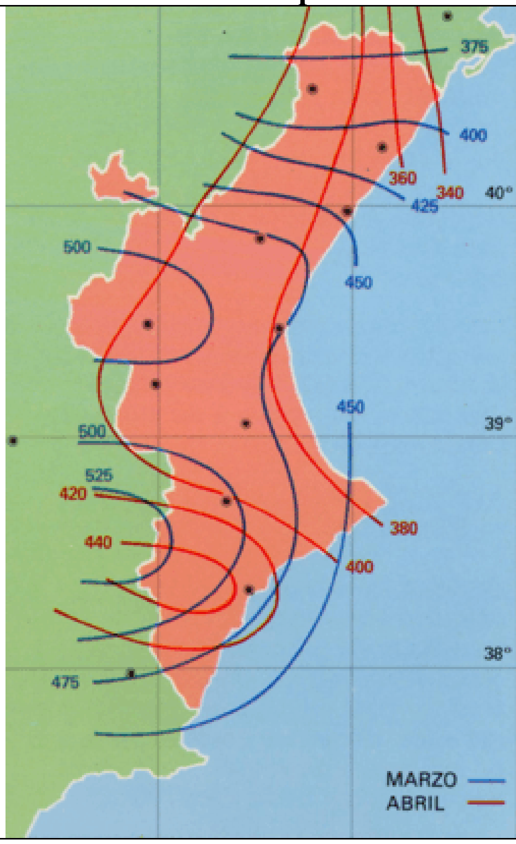
In the maps the global solar radiation is shown with a monthly average values for a daily radiation, expressed in cal/cm^{2}day. Lines show the points with the same radiation value in these units.

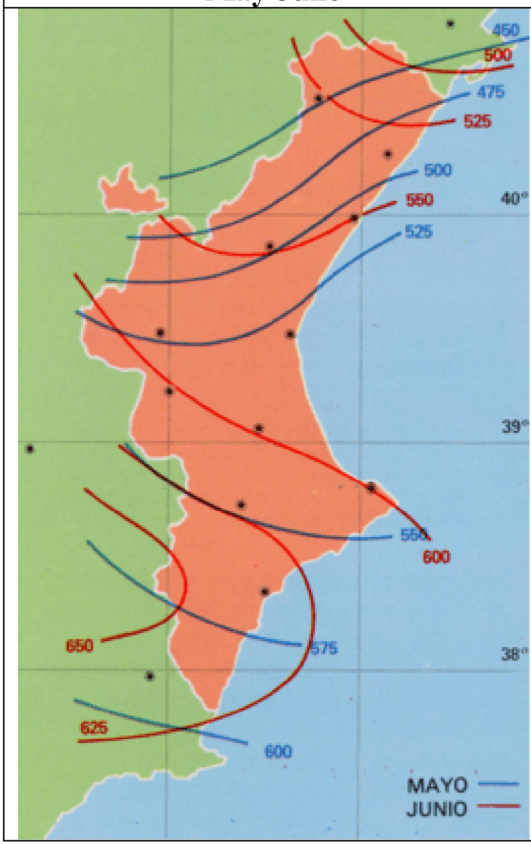
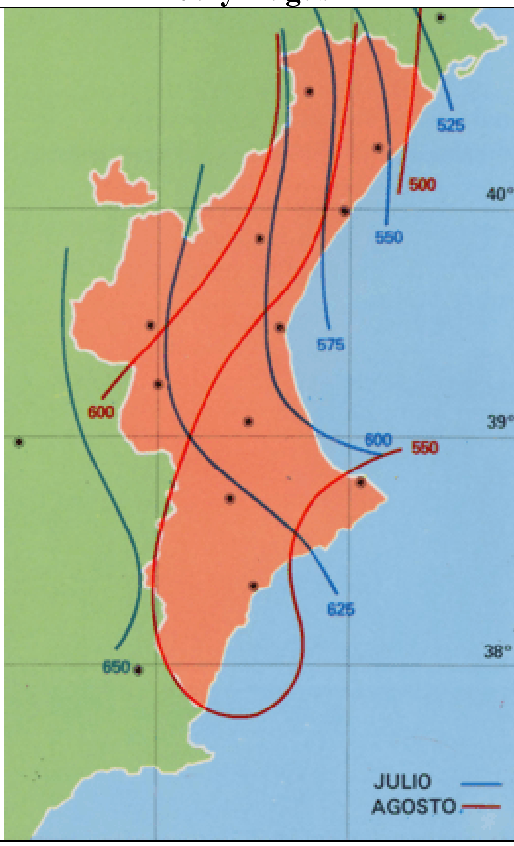
To express the data in MJ/ m^{2}day only it is necessary to multiply the obtained data:

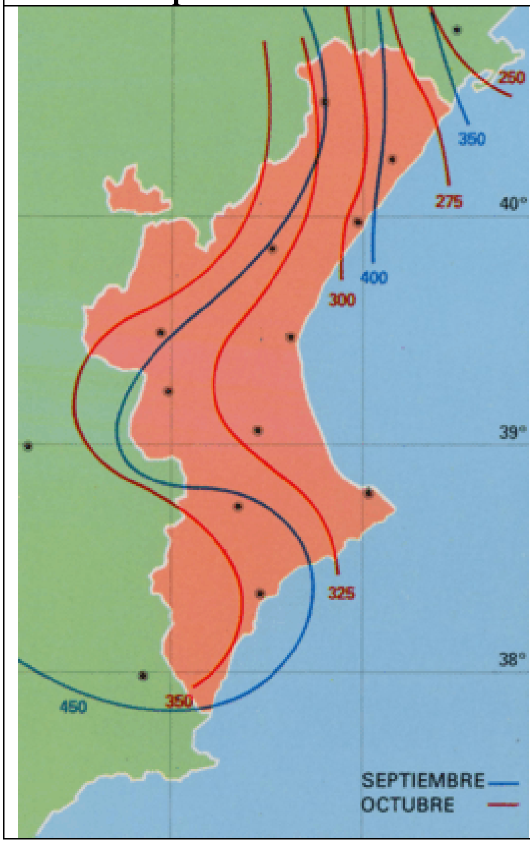
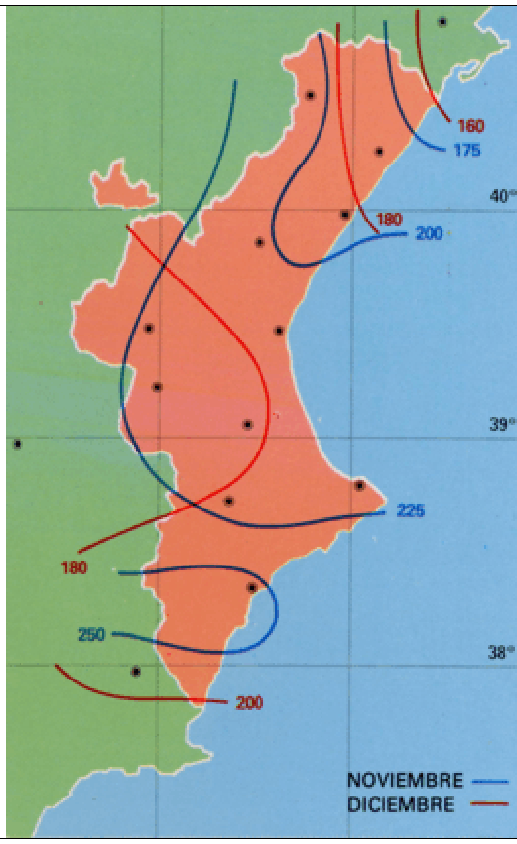
$$0.048 \cdot \text{cal/cm}^2\text{day} = \text{MJ/ m}^2\text{day}$$

[30] AVEN: Valencian Energy Agency, C/Colon 1, 46004 Valencia. Web: www.aven.es

MAPS

January February	March April
	

May June	July August
	

September October	November December
	

Figures 5.4.1.1: maps showing the solar radiation for different months. Valencian Energy Agency source

5.4.2. Solar Radiation Table

Many programs to calculate the solar installation in the domestic sector, thermal or photovoltaic, need the global solar radiation data from the horizontal plane to estimate the supply of solar radiation. This table shows the global solar radiation data intercepted for a plane with horizontal inclination and with a midday orientation. The data are in **MJ/ m^2day** for each month. The last two columns indicate the annual radiation and the radiation during the 6 coldest months in winter.

Table 5.4.2.1: Solar radiation data

Angle	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual radiation	Winter
20	12.9	14.7	18.9	21.2	22.1	23.2	24	22.3	20.3	16.4	13.2	11.0	6602	2624
25	13.7	15.3	19.3	21.2	21.8	22.6	23.5	22.2	20.5	17.0	14.0	11.8	6694	2750
30	14.5	15.9	19.7	21.1	21.3	22.0	22.9	21.9	20.7	17.5	14.7	12.5	6748	2858
35	15.2	16.4	19.9	20.9	20.7	21.3	22.2	21.5	20.8	18.0	15.4	13.2	6763	2948
40	15.8	16.7	20.0	20.6	20.1	20.5	21.4	21.0	20.7	18.3	15.9	13.7	6740	3020
45	16.3	17.0	19.9	20.1	19.3	19.5	20.5	20.4	20.5	18.5	16.3	14.2	6679	3072
50	16.7	17.2	19.8	19.5	18.5	18.5	19.5	19.7	20.2	18.6	16.6	14.6	6580	3105
55	16.9	17.2	19.5	18.8	17.6	17.5	18.5	18.9	19.7	18.5	16.9	14.8	6444	3119
60	17.1	17.2	19.1	18.1	16.5	16.3	17.3	18.0	19.2	18.4	17.0	15.0	6272	3112
65	17.1	17.0	18.6	17.2	15.5	15.1	16.1	16.9	18.5	18.1	17.0	15.1	6065	3086
70	17.1	16.7	18.0	16.2	14.3	13.9	14.8	15.9	17.7	17.8	16.8	15.0	5827	3040

For the calculation and installation of solar panels in our bioclimatic house it is necessary to use these data as a guide to calculate the characteristics of the power, area, and quantity of collectors that the house will require to work. In the next saction the calculation and technical characteristics of the solar installation selected are shown.

5.5. Comfort Conditions for bioclimatic houses

The first step before conditioning a building is to analyse the comfort conditions required. The comfort conditions are difficult to establish because this depend on the person and the type of activity that we are carrying out and the problem starts when we have more than one person in the building (normal thing) and with the same conditions and the same level of activity for example, some occupants are cold and others not. The general idea is that the comfort conditions depend on the person however there is a guide or a general data that can be followed.

In Spain the obligations in internal comfort for building are included in the Legislation. Regulations for heating and air conditioning are described by the UNE 100–013–85 reference 5 law which states that it is compulsory to maintain the comfort conditions between determinate values, maximum and minimum for winter and for summer. These values are of temperature, humidity, wind speed and acoustic comfort as well.

For winter

Temperature: 18ºC < Temperature < 22ºC
It is common to establish the temperature in 20-21ºC
Relative humidity: from 30% to 65%

For summer

Temperature: 23ºC < Temperature
It is common to establish the temperature in 25ºC
Relative humidity: upper to 55%
Other data are:

Ventilation

- minimum of 8 m^3/hour/person
- normal of 30 m^3/hour/person

Wind speed < 0.25 m/sec

Acoustic level
Housing: 35 dBA
Offices: 40 dBA

As general data, we are going to consider some guide values to analyse the comfort conditions for our project and to show that it is possible to maintain a temperature from 20ºC to 24ºC in the interior of the house and a humidity of 50%-55% during the summer and 35%-60% during the winter.

Our goal is to prove that in the bioclimatic house analysed it is possible to keep an appropriate temperature and humidity and a high air quality with natural ventilation.

5.6. The Bioclimatic House Description

BIOCLIMATIC SINGLE HOUSE CHARACTERISTICS

To explain the characteristics of this house we expose here the main factors that have been considered and followed before and during the construction thinking in every moment about how this house would work during the life period.

5.6.1. The house

THE HOUSE

Figure 5.6.1.1: Front face of the Boclimatic House located in Montserrat, small town of Valencia. Project of the Architect Luis de Garrido. (Bioclimatic and ecological projects)[31]

South Facade of the bioclimatic house: the picture shows a general view of our bioclimatic constructions and it is easy to see some bioclimatic and ecological elements as the solar panels, the glass surfaces, the protections in the windows to avoid or not the entrance of the direct solar radiation. In this main face the used materials in the construction can be observed and the most important are wood, glass and concrete.

[31] The Bioclimatic House studied is a Project of the Architect Luis de Garrido.

5.6.2. Site plan

SITE PLAN

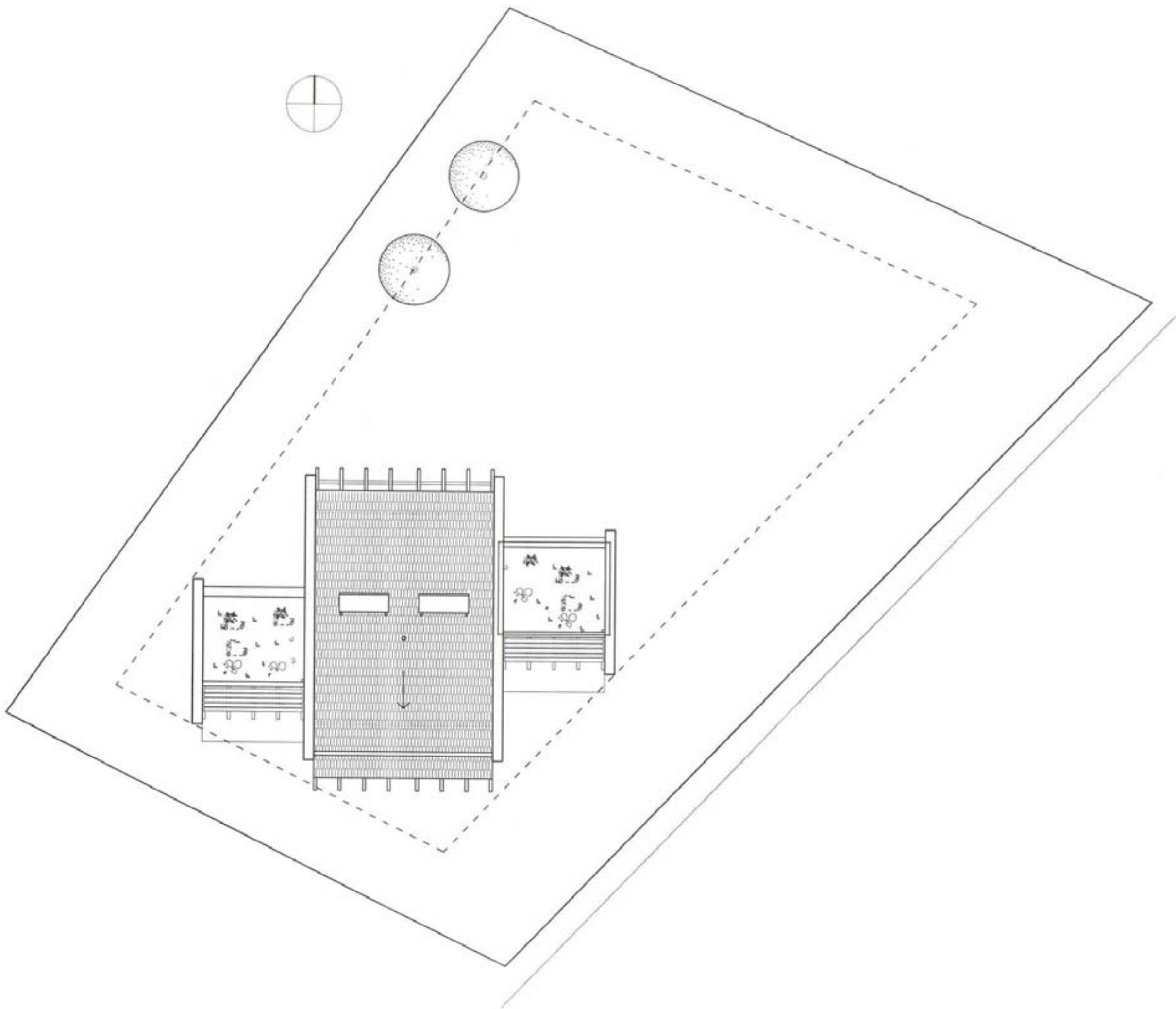
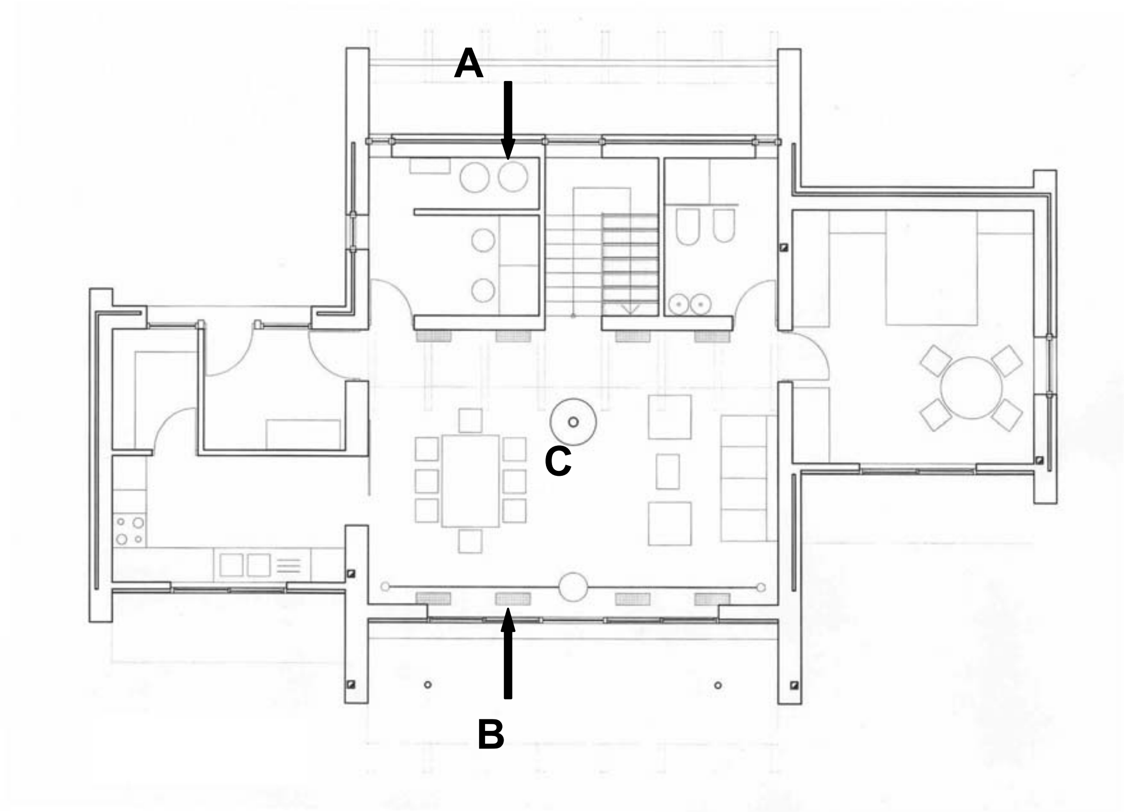


Figure 5.6.2.1: Site plan of the Bioclimatic House Project.

House and terrain plan: This map shows the terrain, the parcel where the house is built and it is possible to see that the main face is oriented to the south as every bioclimatic construction. The green covers and the solar panels are shown and it is possible to see the wood protections for the windows. Around the house there is a garden, green area which is a good option to integrate the house with the environment.

5.6.3. Layouts

GROUND FLOOR



A: The small room where the deposit and the control for the solar collectors is located. Here there is a systems where it is possible to see the water temperature and to keep the control.

B: grill for the ventilation of the interior. There are 4 grills and not 8 as it is possible to see in the layout.

C: Chimney, specific design.

FIRST FLOOR

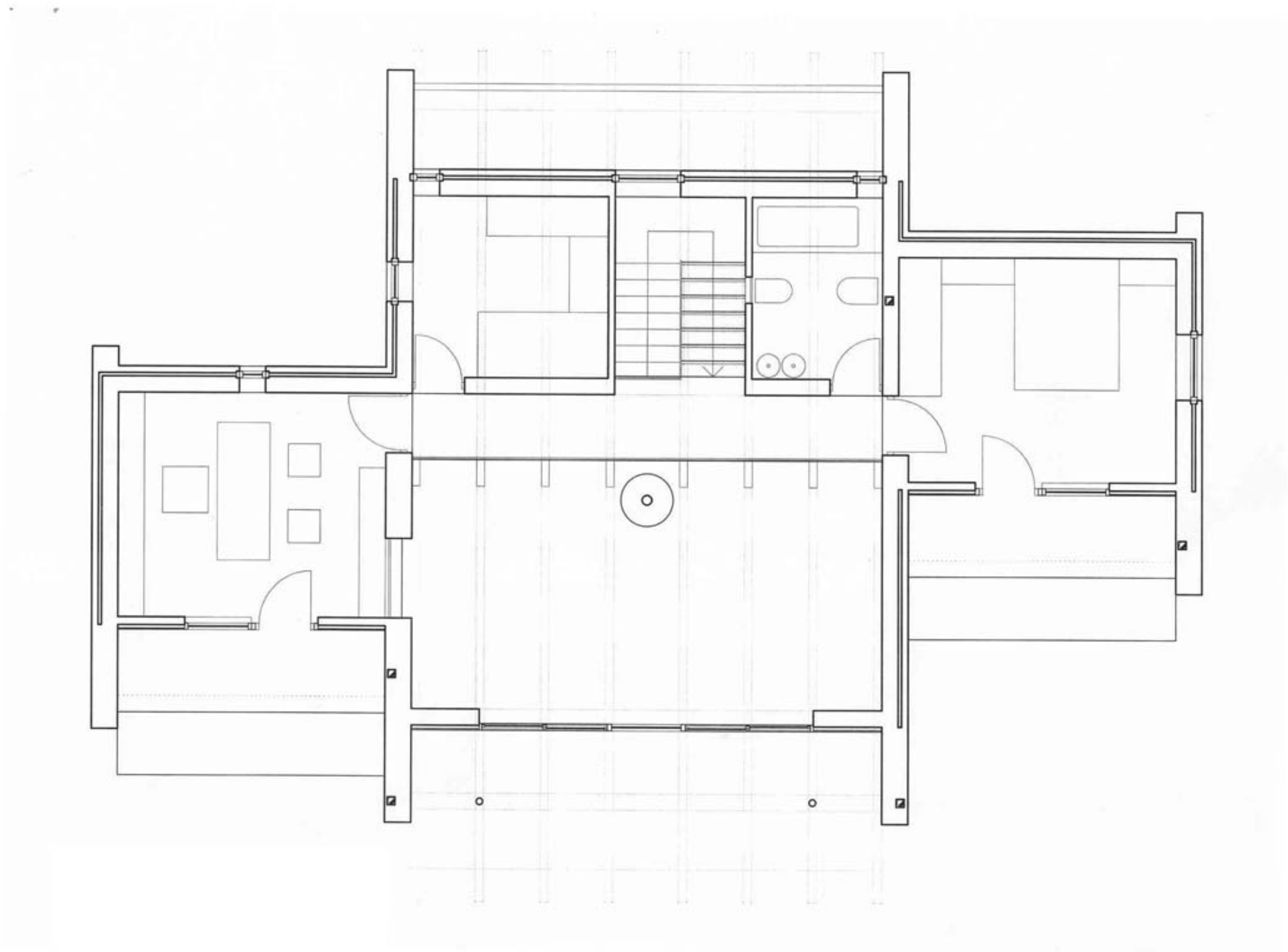


Figure 5.6.3.1: Layouts of the bioclimatic house project.

The building's orientation is North-South and in the layout of the house in possible to see that we get a satisfactory layout of the interior rooms. In fact the living room, the kitchen and rooms where the occupants spend a lot of time during the day are oriented towards the south, whereas the bedrooms, bathrooms and other rooms, stairwells and store rooms be oriented to the north. This layout is characteristic of a solar design.

The north face of the building does not receive a lot of natural sunlight and for this reason we try to locate the main bedrooms on the east side in order to have a good morning light in these rooms.

5.6.4. Section of the house

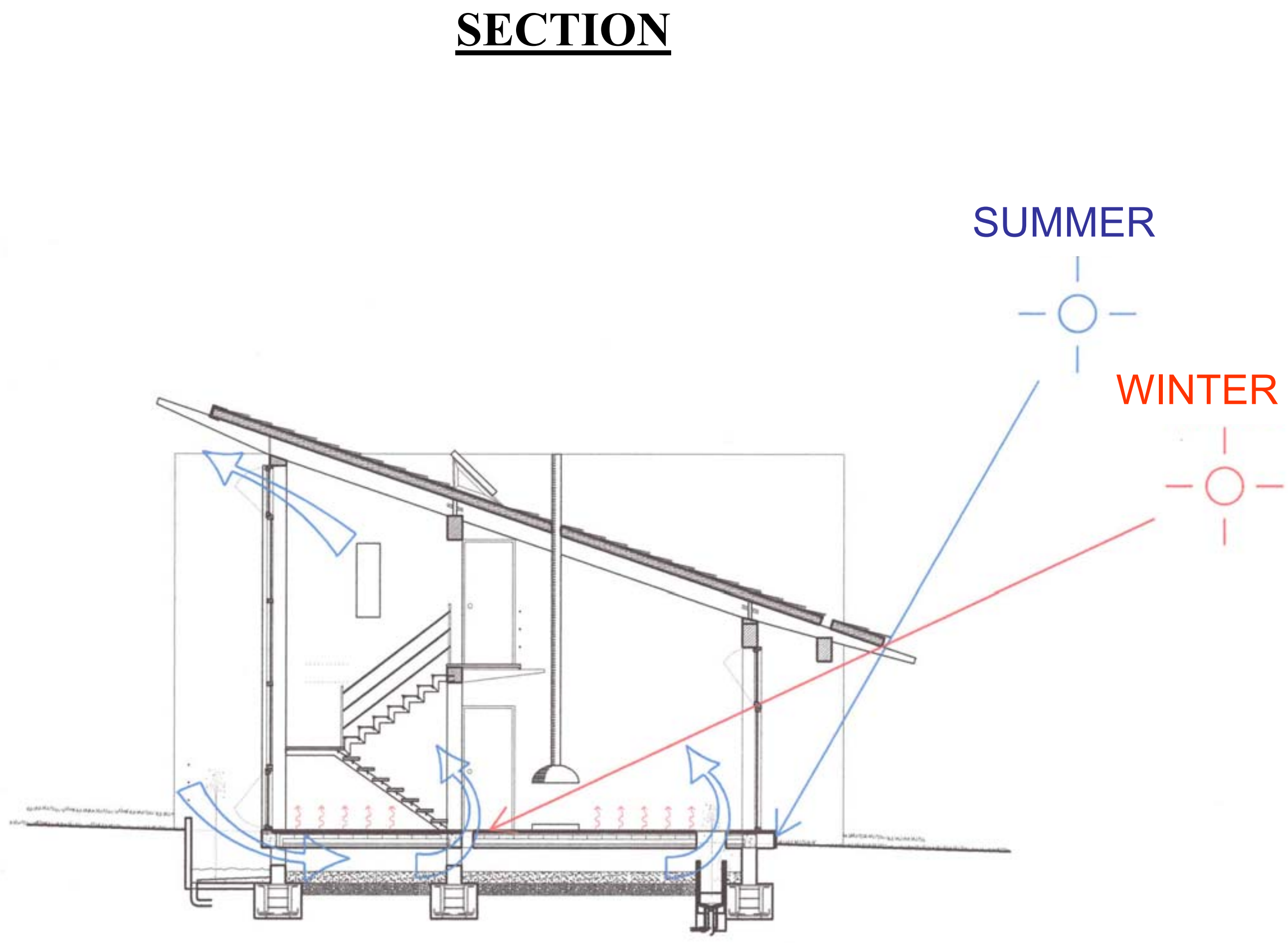


Figure 5.6.4.1: Section of the bioclimatic house Project

The section shows the most important bioclimatic elements used for this construction. They are as follow:

- The orientation N-S
- The solar panels on the roof. The roof has an optimal inclination to get efficient passive solar gains and to use the maximum solar radiation.
- The biomass system for heating (Modern chimney)
- The passive solar penetration
- The natural ventilation system
- The water room under the floor

It is vital to construct the building in this way to permit the sun's rays can penetrate well inside in winter and to avoid the penetration of them in summer using a shade provided by roof overhangs and deciduous trees located in the garden and surroundings.

5.6.5. Sustainable Factors Achieved

The exceptional characteristics of the house are:

- **Sustainability**

  To carry out the Project 100% sustainable criteria have been followed to design the house. All the materials and technologies have been selected using a completed ecologic catalogue, choosing the most convenient elements. The sustainable indicators defined in the proposed strategy for sustainable development have been used (point 4 of this thesis)

- **Multimedia and high technology with access to internet (wide band).** The domotic system is located in the kitchen of the house. It is a screen with an innovative design and it is possible to control function and activities of the house.

  We can control the blinds, the curtains, the garden watering, the doors, lighting, the heating system, the swimming pool, the water leaks and the gas leaks, the breaking of glasses, the house hold appliances and others elements. Moreover, it is possible to have access to internet to look for recipes, it is an outlook, and it is possible to control the food in the fridge and to know if we need to buy or to change something.

- **Cost**

  This house is an example of a 100% ecological and 100% bioclimatic house (without heating system and without air conditioning but with an advance domotic control system) which can cost the same as any non bioclimatic house.

  Only it is necessary that the architect, the builder and the promoter make an effort to decrease the costs and to increase the bioclimatic conditions.

- **Bioclimatic house**

  The house has been projected with bioclimatic criteria, in the way that only because of the shell; the house can heat up in winter and can get cooler in summer.

Moreover, mechanical systems are not necessaries for conditioning and the main reasons for that are the N-S position or direction of the house, the distribution of the rooms, the position of the cavities for the ventilation and the protections for the climate conditions.

Practically, the house is characterised by a great greenhouse. In fact, the 2 levels living room where the other rooms have their entrances is warm in winter because of the greenhouse effect generated by the big surface of glass and windows.

In the upper part of the stairs there is a big and useful opening to take out the heated air in summer by a chimney effect.

- **Construction over a water room**
  To refresh the house in summer it is possible to extract air from the north face and this air can pass through the under-floor where the big water room is located. It is possible to full this space and with a simple heat transfer method the air can be refreshed.

  The fresh air comes into the house from the floor, through the whole space, to the upper rooms of the house, and finally it is going out in this place by natural convection and a chimney effect.

- **Renewable in the house: thermal solar energy and heating by biomass system**
  The house uses a thermal solar energy system with solar collectors to heat the water of the house.

  The house has an innovative chimney which has an attractive design and is heat producing. As we have an extreme bioclimatic design, the quantity of heat provided is really small. This chimney is the unique shown in a museum (Guggenheim de New York).

Figure 5.6.5.1: Chimney which works by biomass

- **High efficiency and saving in energy consumption**

  Due to the South orientation or position, the bioclimatic design, the insulation and the thermal inertia, the house consumes only a 10% of energy that it is used in a conventional house. This means that we have a 90% of energy savings.

- **Healthy**

  The house has been built with healthy and ecological materials not harmful for the residents and the environment and to thinking in every moment about to provide the well-being of the people who is living in the house. The materials used are named in one of the next points.

- **Green Cover**

  The house has a green cover on the roof of land (50 cm) where vegetation can grow. The advantages are the insulation, the thermal inertia (heat and cold accumulation) the oxygenated surrounding and with the possibility of not modify the total surface of green spaces in the plot.

  The green cover is formed by plants with any maintenance and minimum water needs.

- **Rainfall water system**

  The house has a rainfall water system but has not system for waste. The watering system is carried out with water from the swimming pool and from a deposit. The house has a system to separate grey water, rainfall water and black or residual waters.

In the swimming pool there is a water treatment systems consisting of a “diatomite” filter.

- **Technical aspects**

Building type:	Single family house
Usable area:	133´88 m2
Built area (gross):	179´30 m2
Location:	Valencia, Spain
Completed:	January 2003
Costs:	
Cost (only construction):	77000 pounds (aprox)
Total cost. (Terrain, Project, decoration, etc):	115000 pounds (aprox)

It is possible to see that the total cost of this kind of houses is not high in excess. Any house in the city can cost more or less the same, even more in some cases, depending on several aspects as location or other characteristics, but we consider that this house is a high quality building with an optimum cost and can provide a high quality of life to the occupants being closed to the city.

5.6.6 Photo Gallery of construction details[32]

Figure 5.6.6.1: The south face of the bioclimatic house. Project of Luis de Garrido architect

<u>DETAILS</u>

<u>North face:</u>

It is possible to see less area taken up by windows or glass surfaces than in the south face of the house. This is due to the orientation and it is done to get a good level of thermal comfort.

The North Face is protected for two high pines. They hadn't cut down when the house was built.

[32] The Bioclimatic House studied is a Project of the Architect Luis de Garrido. All the photos have the same reference. It is the same project

Figure 5.6.6.2: The north face. Trees to protect the face. Project of Luis de Garrido architect

Figure 5.6.6.3: Detail of the entrance in the north face. Project of Luis de Garrido architect

Figure 5.6.6.3: Detail of the ventilation system. Project of Luis de Garrido architect

Detail of the natural ventilation systems. These hollows under the floor of the house are located in the north face and they are useful because the cold wind comes into the house throughout them.

During the summer the cavities have been closed due to the high temperatures outside, and there is water in the hole with a cover of small stones

Sourronding area

Figure 5.6.6.4: The sourrondings. The location or place where the house has been built

5.6.7 Interior of the house

5.6.7.1. Photo gallery of internal details[33]

INTERIOR OF THE HOUSE

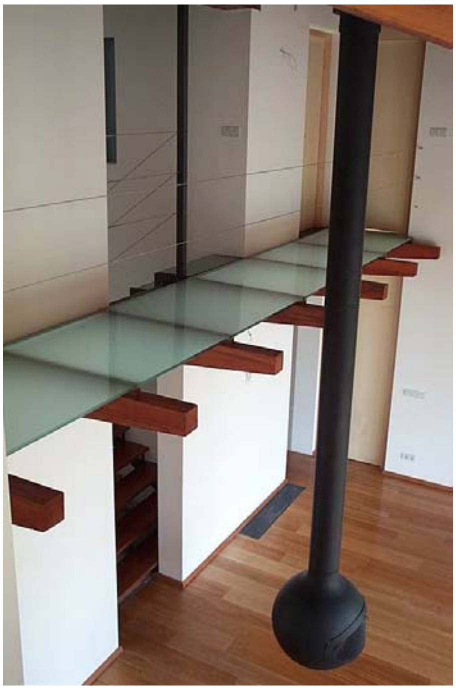


Figure 5.6.7.1.1: corridor in first level and view of the chimney

Figure 5.6.7.1.3: View of the ground and first level.

[33] The Bioclimatic House studied is a Project of the Architect Luis de Garrido. The same reference for the photos of the interior of the house

5.6.8 Result Data for the house

Number of occupants: 3

Characteristics of the occupants:

In the house live a couple with a child of 8-10 years old. They are a common family, with a medium social status without economic problems and without health problems.

The family has been living in the house since the last February and they agree that the comfort conditions and the good characteristics and quality of life in this house are better in comparison with the house where they were living before.

Time of occupancy (hour/day): 8 hours/day average

5.6.8.1 Comfort conditions obtained in the house

Comfort conditions[34]:

- T and humidity

  20ºC to 24ºC in the interior of the house

  No problems with the internal humidity

- Ventilation: in summer is better at the end of the day because during the day the outside temperatures have been really high, but in general, the natural ventilation works well.

- Wind speed < 0,25 m/sec

- Acoustic level: under the limits, (< 35 db). Moreover, it is a quiet place without traffic, noises, and with not too much neighbours.

[34] Confort condition data from the occupants. They have proportioned the data and their feelings living in the house. Therefore, it is possible to conclude in this way

Real data inside the house[35]:

Appropriate temperature and humidity and a high air quality with natural ventilation (the data are estimated, average)

Tables 5.6.8.1.1: Data inside of the house and the occupant comments

	winter		summer	
	day	night	day	night
Temperature	22	22	25	22
Humidity	ok	ok	high	ok
Ventilation	ok	ok	Could improve	ok
Wind speed	ok	ok	ok	ok

Acoustic level		
day	night	weekend
<35 db	<35 db	<35 db

The next comments and conclusions have been obtained asking to the occupants. It coul possible to visit the house and to see how this house is working and the man who is living there explained every element of the house. He is a proffesional engineer and he could ask all the questions about the house.

Comfort in winter: Winter is cold but in the house it is possible to have a good internal comfort with the use of the chimney.
The thermal inertia and the insulation work really well together. The degree of satisfaction during the winter is high but always considering that it is necessary the use of the chimney.

The lighting during the winter is also good; the house is located in an optimum place and can receive the maximum solar radiation and the maximum daylight during the day.

[35] Data inside the house. The data have been recordered in the house and they have been asked to the occupants to know if the data are coherent.

With this it is possible to save energy and to gain luminosity. This is due to the big dimensions of the glass and the orientation.

Comfort in summer: Summer is really hot with a high humidity and the efficiency of the house could be improved with the correct use of the water room. The problem of the water room has been that during this summer, the temperatures outside have been really high (35-40º C) and it is necessary a minimum of 2ºC of temperature difference between outside and inside the house.

During the night the results are better because the temperatures decrease.

A possible solution could be to have more distance between the air entrance and the living room. Maybe the entrance could be located deeper but could be more expensive and difficult to build.

Despite this, it is possible to have good comfort during the summer without the use of air conditioning systems and without electrical ventilation devices.

In summer, the lighting has a little problem. The luminosity is in excess, too much daylight and it is necessary to cover the windows.

In conclusion it is possible to say that during the summer could be convenient to improve the comfort conditions but the bioclimatic elements work well.

5.6.8.2 Solar Installation System

Solar collectors:

Number of collectors: 2

Area: 4 m^2 in total

Angle: 50º due to the solar radiation in winter

Domestic hot water system: Deposit of 3 litres with forced circulation. It is possible to have a service of hot water during 3 days even in cloudy days.

Water temperature in the store: 84º C

Figure 5.6.8.2.1: Temperature control system. The small screen shows 84 ºC.

Figure 5.6.8.2.2: Domestic hot water system with a deposit of 3 litres located in small room inside the house

6.5.8.2.3 Ecological materials

In this point, the materials used in the construction are grouped. It is possible to see which materials have been used and which not. The main elements can be show in the photos of the previous points.

Floors:

In the ground floor parquet floor has been used. This is a 0.5 mm of wood parquet floor. In the first floor a cork floor has been used. This type of material is more expensive and it has been import from Austria.

Roof cover:

Birch plywood of 1 cm

Insulation camera of 10 cm

Natural cork

Virok panel and rubber panel

Walls:

With natural and ecological paints

Kitchen and bathroom:

Without glazed tiles, only the necessary in the bathrooms (half wall more or less)

Stairs:

The internal stair is made of steel structure with steps of glass

USED MATERIALS	NON USED MATERIALS
• Wood without additives only treated with natural oils. • Types of wood: red cedar, pine and maple tree • Steel in doors of the garden • Concrete and wood as structural materials • Glass, slate, stones • Others named before	• Ceramics • No use of PVC • Aluminium • Bituminous materials • No synthetic fibres

Table 6.5.8.2.3.1: used and non used materials

PART 2

RESEARCH CARRIED OUT ABOUT THE KNOWLEDGE OF BIOCLIMATIC CONSTRUCTIONS

5.6. INTRODUCTION

The part 2 of the case study consists of conclude if the inhabitant, the users of buildings, the citizens, the architects, professionals, people in general have enough information about this type of construction, the bioclimatic and ecological buildings in the Mediterranean region. Due to the difficulty to carry out the research, the study has been focused in Valencia, but it is possible to take the results as an example and to give a general idea about the development of bioclimatic houses in other areas of the Mediterranean.

This is only a simple study but the goal is to give a general idea about the present and future situation of this type of construction.

The purpose of this research was to establish what are the main barriers for these constructions, to propose a number of solutions and alternatives, to know the optimum method able to simplify and promote the bioclimatic principles to be adopted in future constructions starting today, and one of the most important things is to provide information to everybody interested in this field.

To think about the study it is important to take methodological decisions and to establish different conditions for different kind of people in function of their knowledge level about this topic.

It is necessary to prepare different studies for different experts such as engineers and architects, and for the residents, that is, people who are not expert on this field.

The aims are:

- To find whether people are informed on bioclimatic and ecological constructions and in which level.
- To know whether people understand what a bioclimatic design means and the basis to build in this way.
- To discover whether professionals as designers and architects have applied some of the bioclimatic principles on their projects.
- To know whether the benefits (comfort, energy efficiency...) of this type of construction are know for them.
- To ask the personal opinions about the level of information on the subject.
- To conclude about the situation of the bioclimatic and ecological constructions in the area.

This questionaire was prepared and asked to different persons. I made this questionnaires to 3 groups of people, professionals, common people and in low number to people who live in these type of houses, including the family who is living in the bioclimatic house of the case study.

The questionnaire had not been distributed. It has been asked directly to different people. Firstly, Ten common persons have been asked about this theme. Secondly, 10 persons included in the proffessional group have been asked about the same theme, and finally, only 4 families (4 persons) have been asked about their house.

The group of professionals consist of 7 architecture students and 3 real proffessionals due to the facility in achieving students.

This study could be done in more detail and with more data during more time and with more different groups of people. In this project, it is shown only an overview and the first idea to carry out one more difficult and complete study.

5.7 Statistical Study

5.7.1 Formulated Questions

<u>Group 1</u>: Professionals (architects, engineers and students of architecture and engineering)

1. Have you ever heard to talk about bioclimatic constructions or ecological houses?
2. Have you ever seen a bioclimatic construction or ecological house?
3. Do you know how to integrate ecological and bioclimatic elements in buildings?
4. Have you carried out a complete project with these characteristics?
5. Do you think that it is possible to build an ecological house with similar costs that a conventional house?
6. Do you think it is possible to improve the conditions, the quality of life, to improve the energy efficiency with energy savings and to gain in internal comfort with this kind of houses?
7. Do you think that it is convenient to invest in this kind of project in order to promote the bioclimatic principles in the construction?
8. Do you know if the Administration invests in programs for the formation of technical staff in this field and if there is some kind of help to promote the bioclimatic constructions?
9. Do you think that it is necessary more information about this kind of projects?
10. Are you interested in receiving free information on this kind of houses?

<u>Group 2</u>: Non professionals

General questions: Citizens

1. Have you ever heard to talk about bioclimatic constructions or ecological houses?
2. Have you ever seen a bioclimatic construction or ecological house?
3. Do you think that bioclimatic constructions would be more expensive than conventional houses?

4. Do you think that it is possible to use renewable energy sources as the solar energy in your house to cover the necessities of heating and electricity?
5. Do you think that with a bioclimatic building the energy bills could be reduced?
6. Do you think that your home is a healthy and a comfortable place to live in it?
7. Are you worried about the preservation of the environment, the energy efficiency, the comfort in buildings and the reduction of toxic emission?
8. Do you know if the administration promotes investments and helps for this kind of constructions?
9. Do you think that it is necessary more information about this kind of projects?
10. Are you interested in receiving free information on this kind of houses?

Specific questions: residents of buildings that can be considered completed with some bioclimatic principles

1. In general terms, are you happy with your bioclimatic house where you are living?
2. Do you think that you are living in a comfortable house?
3. Is the temperature of your house comfortable on sunny days?
4. And on cloudy and raining days?
5. Do you often use your heating system in winter?
6. Do you achieve effective saving due to the use of the collectors systems for heating water and the presence of the greenhouse?
7. Dou you think that there is any problem in the use of this kind of houses?
8. Is there direct solar radiation in the main rooms of the house?
9. Have you notice if the air quality in the house has improved with the natural ventilation?
10. Do you think that the temperature and humidity are more comfortable in the bioclimatic house?

5.7.2 Result of the study

Period of the study: Summer period of 2003 in Valencia, Spain.

Asked people:

- Range of age: from 22 to 65
- Different social status
- Different political thoughts
- No tourist people asked to achieve a local result.

<u>Graphics and statistics:</u>

<u>Group 1</u>: Professionals (architects, engineers and last year students of architecture and engineering and postgraduates)

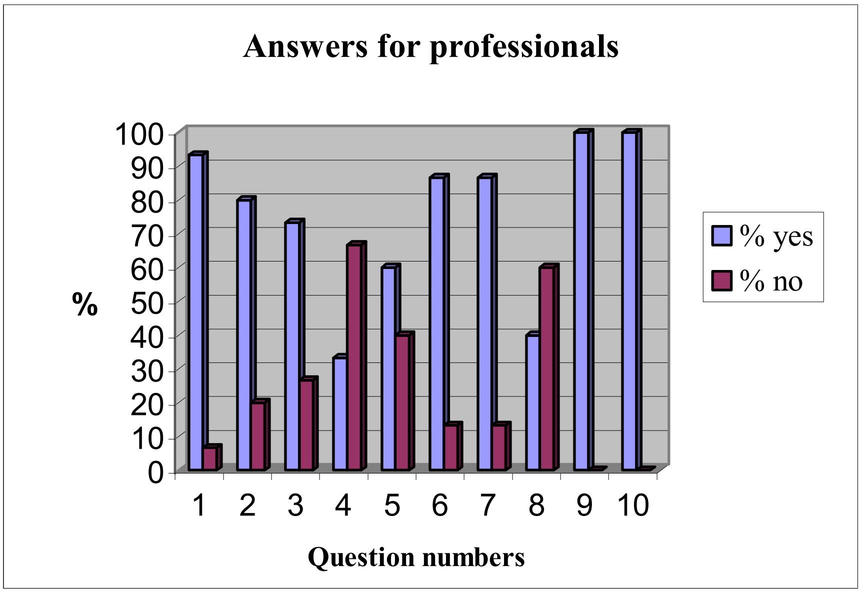


Figure 5.7.2.1: Results for professional group

<u>Group 2</u>: Non professionals

- **General questions: Citizens**

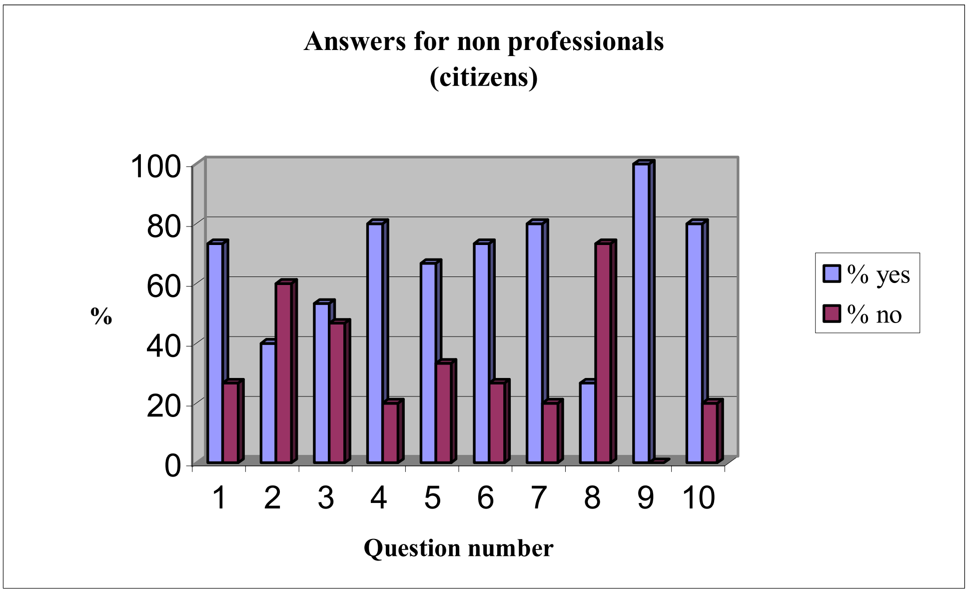


Figure 5.7.2.2: Results for citizens

- **Specific questions: residents of buildings that can be considered completed with some bioclimatic principles**

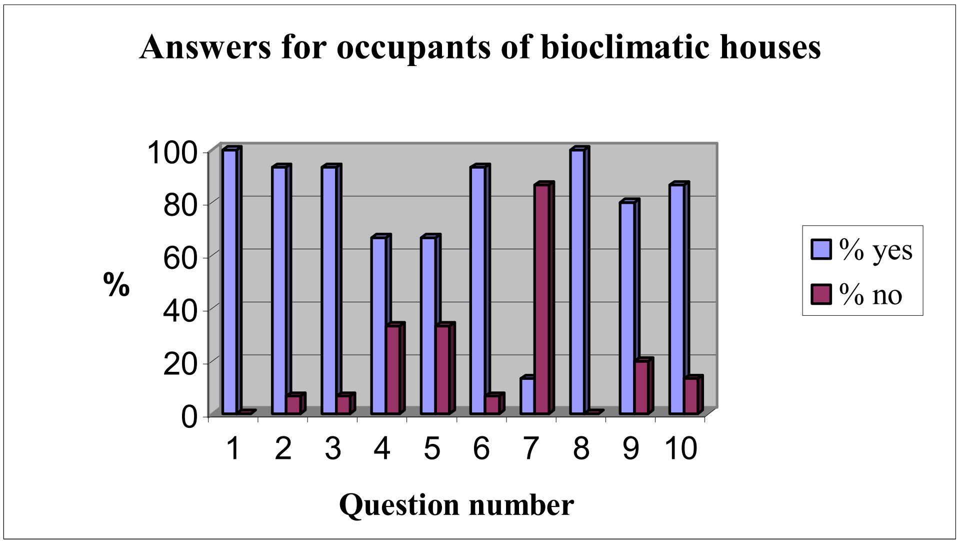


Figure 5.7.2.3: Results for occupants of a bioclimatic house

5.8. Conclusions

To elaborate and analyse the result in order to conclude about our proposal which was to know the level of knowledge about these bioclimatic constructions in the Mediterranean area of Spain, it is useful to use the graphics obtained after to carry out the questionnaire and the data treatment.

Some thoughts are easy to conclude because the questions were really simple, but with others it is possible to extrapolate the data and to achieve more concrete and important conclusions. By this reason would be recommended to carry out an study in depth considering more factors and important element thinking about to divide in more different categories the asked people.

However, our result have been really useful to start a possible future research in depth and the more obvious conclusions and comments are as follow:

- Professionals are culturally and technically informed but not too much professionals have participated in a project with bioclimatic characteristics. Really, all the professionals have heard about bioclimatic architecture, many have seen a bioclimatic building and some have really contributed to some of these constructions. But a positive general opinion is that the situation is improving and the development is growing. One reason for this is that new generations of professionals seem really interested in this field.
- All of them are conscious of energy savings and the ecological benefits in general for these buildings but we have noticed that there is a lack of information about the programs and investments carried out by the Administration. This lack of information about the funds and investments is shown for non professional people.
- It is possible to say that in the area of Valencia and Catalonia there is an energy efficiency and energy consumption plan and it includes programs for the domestic sector in local and the community level.
- There are agreements and collaborations between institutions and professionals.
- It is necessary to continue with this growth and to invest more in this type of constructions giving more information about the availability of funds and economic

helps from the European Community and in a low level, from the local administration and government of the place.

- Talking about the citizens, non professional people, it is possible to say that more useful and completed information is needed for this projects, the possibilities, the characteristics, the promotions and in general about how to get information about it.
- If we think about the comfort conditions they think that their homes are comfortable but not really healthy because of the surroundings, the vicinity, the location, the high density of population and the free spaces, etc. One reason for this could be that the study has been carried out in the city and not in the countryside or more quite areas than the city where the development and construction of bioclimatic houses is higher that in the city.
- We consider necessary to promote and to pay attemption in future bioclimatic constructions or rehabilitations in the city.
- People who think that they are living in a comfortable and healthy place could be wrong if they are not expert. If an expert would analyse their houses would be possible to find unhealthy elements frequently.
- If we analyse the results for the occupants it is possible to say that the results are positive. A high level of comfort conditions is achieved at homes. The level of satisfaction is high and they agree about the improvements and benefits such as the natural ventilation, the temperature and humidity in the interior, the use of solar elements and the long period of daylight due to the orientation and, in general terms, every bioclimatic characteristic.
- It is possible to observe that in the case of high technology houses it is easy to know and to control how that house works.
- An important aspect is that the occupants are conscient of the effective energy savings and the reduction in electricity consumption, maybe due to the use of daylighting and the presence of bioclimatic components as the greenhouse for example.

To conclude we can say that more information about the bioclimatic and ecological constructions would be required and it could be possible to prepare a campaign on different levels of information about the main aspects of the bioclimatic constructions in this area.

With the campaign would be possible to promote, identify and clarify the advantages of these constructions in terms of energy saving, internal comfort, environment conditions, indoor air quality and the new applied technologies.

Could be good to promote and develop an university training in bioclimatic and ecological and healthy aspect for buildings for undergraduate and postgraduate students with the creation of different courses and seminars

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