Greek bio-climatic design and the Sustainable Development

Joseph STEFANOU & Michalis SIAKAVELLAS & Roido MITOULA

Joseph Stefanou, Professor of National Technical University of Athens (N.T.U.A.), Patision 42, 10682, Athens, e-mail: joseph@central.ntua.gr

Michalis Siakavellas, Dr. N.T.U.A., Testing Research and Standards Center of Public Power Corporation, 9 Leontariou st.,Pallini, Athens

Roido Mitoula, Lecturer of Harokopio University of Athens, Department of Home Economics and Ecology, Eleftheriou Venizelou 70, 17671, Athens, e-mail: mitoula@hua.gr

1 INTRODUCTION

The continually increasing consumption needs the excessive growth of the population and the improvement of living conditions of a part of the population has led to the rapid increase of energy consumption in the last two decades. The production of petrol has multiplied by a factor of six in the last decade, while the demand for electric energy is multiplied by a factor of ten almost every decade. The thoughtless use of conventional sources of energy has greatly contributed to the increase of the emissions of fumes, which destroy the ozone layer and tragically downgrade the environment gradually wiping out its ecosystems. Greatly responsible for increasing environmental crisis are industry, transport and powerhouses, but also the built environment.

By the term “built environment” we refer to the total space where human construction have developed including first of all buildings which cover the needs of housing, occupation and recreation. According to the size of buildings and relative substructures, the built – environment is characterised as urban, semi-urban and rural. Occupying with the urban environment of big cities becomes extremely interesting for the Greek reality if we consider small building blocks, the increased height of buildings and the big size of the city which perplex the study of the bio-climate. The “climate phenomena” which are connected to the thermal and aerodynamic behavior of the cities deal with the phenomenon of “thermal island” (differences in the temperatures between a city and its neighbouring rural area) and the phenomenon of “urban ravine” (changes in the speed and direction of winds as well as the temperature layer of the air at the city high ways) [1].

The first petrol crisis at the beginning of the 70’s alarmed scientists occupied with the designing and shaping of a building and directed them towards the study and research of new forms of energy so as to create a more practical, economical and ecological building. A new need was born for a dynamic approach in which the building is dealt with as a live organism and not as an object of consumption and vanity. In this direction the factor “ecological balance” is a top priority in every design leading architects to the solution of the immediate application of the principles of bio-climatic architecture and ecological construction.

2 ENVIRONMENT AND BUILDINGS IN THE GREEK SPACE

Buildings affect the environment in various ways during their construction, function and demolishing. The environment has a strong effect on buildings as well. Full awareness of this interaction is demanded so as to properly design bio-climatic buildings. Buildings of Greek mega-cities have an influence on the environment creating however, numerous problems like: [2, 3]

- Aggravation of air-pollution, the greenhouse phenomenon and the creation of acid rain because of fume emissions, a fact, which is due to the thoughtless use of conventional energy resources (mainly heating petrol).
- Alteration of the basic ingredients of the atmosphere, water, ground and underground because of chemical emissions that basically came from urban sewage and waste. The above phenomena appear more intense at the most densely built Greek cities.
- Exhaustion of valuable natural resources like mineral rocks and metals during the intensive use of energy for the construction of buildings.
- Downgrading of the surrounding environment in both local and regional level caused by the continual anarchy building. Serious ecological disturbances for example floods fire the extinction of rare plants and animals.
- Serious consequences on the health and quality of life caused by the use of dangerous radioactive non-ecological building materials and by inhaling harmful toxic fumes even in the interior of modern houses of Greek big cities.
- Unstable climate changes in entire areas caused by the disturbance of the cycle of water, oxygen and carbon dioxide. A striking example is the case of the prefectures of Attica and Thessaloniki.

Based on the above, the contemporary design of buildings is led towards bio-climatic architecture with the use of renewable resources of energy and energy saving techniques. The appropriate programming can lead to the gradual of environmental crisis and the upgrading of the quality of urban environment.

3 ENVIRONMENTAL AIMS AND BIO-CLIMATIC ARCHITECTURE

Bio-climatic design was developed in the 1980’s as a new trend of urban design in relation to the local microclimate. With the term “bio-climatic design” we refer to architecture and urban-planning design of buildings and settlements which aims at their adaptation in the local climate and the natural environment, protecting at the same time sensitive areas with rare ecosystems [4]. The climate in micro, medium and micro-scale determines the lighting, airing, design and the energy behavior of the buildings. More specifically, the macroclimate is shaped by the average weather conditions throughout the year. Medium climate is characterised by the influence of the local topography, plantation and nature of the area. Micro-climate, finally, is created by human intervention by which alters the immediate built environment. [1, 5]

Bio-climatic design aims at the exploitation of positive environmental parameters so as to minimise the energy needs of a building throughout the year and save conventional energy [4]. The application of bio-climate architecture can lead to energy independence from non-renewable energy resources up to a 60%. At the same time, it contributes to greatly reducing the emissions of carbon dioxide and other fumes, which aggravate the orthological use of water as well as the wide use of local building materials, which are environmentally friendly. These materials determine in a great degree the thermal and visual behavior of buildings, while their life span has significant consequences on the environment. Many of the building materials like paint, bricks, tapestries and others, contain dangerous substances, which cause pollution to the interior environment. Additionally, some times plinths are used which come from areas high in radioactivity. It has been observed that the traditional ecological materials of pre-industrial period are reliable, have big life span, are not harmful to health and the environment and thus allow saving renewable energy resources [6]. Bio-climatic design incorporates elements connected to the special physiognomy of each area, local cultural inheritance, prevailing traditional techniques and trade-financial habit [7].

More specifically, bio-climatic architecture is mainly a result of an integrated and complex synthesis, which has to do with multiple parameters like topography, soil, orientation, the right choices of openings, and the study of the shell, the choice of the right materials. This however, does not mean that intervention on the existent buildings is limited. With minimum expenditure and friendly to the user technologies, loss of heat can be reduced, buildings can be protected from over-heating, lighting conditions can be improved and noise can be limited. All the above connect bio-climatic design with the terms sustainability and sustainable development, in other words development which covers the needs of contemporary life without posing a threat to future generations [8].

3.1 DESIGN STRATEGIES OF BIOCLIMATIC GREEK BUILDINGS

Various strategies are applied in Greek bio-climatic architecture, which provide the building with the necessary thermal comfort and the suitable natural lighting by making the most of the characteristics of climate in combination with the topography of the land. During cold periods the building should function as a “solar collector” maintaining heat, while during hot periods it should protect the building from the sun by using technical methods of natural cooling. However, there should be plenty of light throughout the year.

3.2 Heating Strategy

Heating strategy aims at providing users with the suitable thermal interior climate with the exploitation of favourable climate elements though the adoption of suitable methods applied on the construction shell so as to minimise the consumption of additional energy. The heating strategy demands:

- The collection of solar radiation,
- The storage of heat with the help of passive elements and
- The “trapping” of heat.

3.2.1 Collection of solar radiation

Adequate solar radiation is achieved when the building functions as a “natural solar collector”. This depends on the design characteristics of the building and its immediate environment, like:

- Its position
- Its shape
- Its volume
- The orientation and the size of its openings
- The arrangement of its interior
- The color of its exterior
- Its relationship with neghbouring buildings
- Its relationship with the natural environment (rocks, trees, water etc.)

When the building does not function as a natural solar collector” then there is a need for the collection of solar energy through the “greenhouse”, an additional passive glass solar space in the south side of the building.

- *Positioning of the building*

Finding the appropriate position for the construction of the building in a piece of land can be aided by the use of solar and energy maps. It has been proved that the location permitting the maximum degree of sun exposure during the winter and the minimum during the summer is the north of the land.

- *The shape of the building*

Research has proved that the ideal shape for any climate conditions is its lengthening towards the axon of East – West and but with various dimensions according to the conditions present. In this way, the building can have a bigger surface towards the South for the collection of solar radiation in the winter [4]. However, we should seriously consider the micro – climate of the area and especially the winds, which should play an important role in the shape of the building.

- *The orientation of the building*

Finding the best orientation possible is affected by the topography of the area, the landscape, the wind, the solar radiation, demands for privacy, the reduction of noise and the local climate [4].

- *The volume of the building*

In order to achieve the best exposure to the sun it is obvious that the small mass of the building should be facing the South so as to increase horizontal, vertical or sloping surfaces while preventing sunlight entering the rest of the building.

- *The orientation and the size of the building openings*

Glass, as a covering material of openings, provides less thermo insulation than walls. Placed to the south it contributes to the best distribution of solar benefits to the building. As far as Greece is concerned, buildings with opening to the south cover thermal needs during mild seasons thus reducing drastically the use of conventional heating. In contrast, openings of different orientation are constructed exclusively for the improvement of natural light and view [10].

- *The structure of the buildings*

The best organization of the spaces of a house in southern mild climates is the following: Spaces of temporary activities like storehouses, stair-ways etc. are placed on the northern part of the building which is cold and dark and accepts little solar radiation. The main spaces are placed on the south where there is plenty of light since it accepts the most solar radiation during the winter and the least in the summer. The western side is preferable for offices etc.

- *The color of the external surface of the building*

It is widely known that dark surfaces appear to absorb great amounts of heat in all wavelengths, while light – colored surfaces absorb radiation of small wavelength which correspond to low temperatures. The effect of color in the external surfaces relative to the absorbed heat is greatly reduced by increasing heat insulation. The hot Mediterranean climate of Greece demands the use of light colors in contrast to those of the north – European climates where buildings are painted in dark color [11].

- *The relation of the building with the neighbouring ones*

Semi – detached buildings are more preferable than detached in terms of thermal benefits. Bigger buildings appear to have a favorable relation with the external surface according to their mass and thus relatively low thermal loss [10].

3.2.2 The “greenhouse” as a passive collective system

The “Greenhouse” is an appendage of the solar space on the south side of the building. Glass or transparent plastic covers the southern and sometimes the eastern or western side. Its function is based on the greenhouse phenomenon blocking big amounts of solar energy reaching the glass surface and its transforming it into thermal radiation in the inner space, while its efficiency is affected by its geometry, the size, the orientation, the inclination. Its use is very popular in the northern, cold climates where there is limited sunshine, opposite to the warm Mediterranean climates where sunshine sometimes exceeds the 250 days per year (Greece) [12].

3.2.3 Passive storage of thermal energy in buildings

The main aim of the techniques for the storage of the remaining heat from the sun in a building is using the stored heat in colder periods. There are two basic systems of passive energy storage, the direct and the indirect. According to the first technique, when a passive material receives solar radiation, a part is stored in its mass increasing the temperature of the material. The second technique is applied when a passive building element is heated absorbing the heat radiated by other warmer elements or is transmitted through the air when the latter has a higher temperature [4].

A. Direct storage passive systems

Solar radiation entering a building through glass openings immediately heats the walls, floors and roofs. The direct storage of heat is effective when the building has big openings towards the south, big thermal mass for the storage of excessive energy and external thermal insulation. In order for this system to be effective “heavy” passive materials of big thermal capacity and minimal cost are required, while at the same time providing direct visual contact with the external environment is provided. Sun protection techniques are demanded in order to avoid overheating during the summer months especially in Greece when big openings of Southern orientation exist [4].

B. Indirect storage passive systems

Indirect storage passive systems collect the received solar radiation through a glass surface, store the heat within the walls and emit it heat to the internal space of the building. The most popular passive systems of this category are the following:

- Mass-wall or glass-wall
- Mass-wall with ventilation or Trombe wall and
- Solar water-wall

\- *Passive systems of mass-wall*

Mass-wall is a glass wall. It is constructed by passive materials of big thermo – capacity and is placed in the southern part of the building. The thicker the wall and its thermo –capacity, the bigger its thermal inertia which results to less thermal profit. Over –

heating during the summer months can be avoided by placing a mobile barrier. This, used during winter nights, can also reduce the thermal loss of the building.

- *Passive systems of mass – wall with ventilation or "Trombe" wall*

"Trombe" is a wall with big thermo – capacity. It is made of concrete and is 30-40 cm thick. Its external side is painted black (big thermo – absorption) while a surface of transparent insulating material is placed in a distance of 3 cm. The distribution of heat at the inner part of the building is done in a natural way (thermo – circulation) or with mechanical means (ventilators, pumps) in case great amounts of heat are demanded [4].

C. *Passive systems of water-solar wall*

In this case, water is used as a material of big thermo – capacity since it has the greatest ability to store heat than any other material with big thermal efficiency [4].

3.2.4 Preserving – "Trapping" heat through passive elements

During the cold periods of the year, buildings have thermal losses because of conductivity and transmission of heat or due to airing or penetration of air. Minimising the losses succeeds the preservation of heating profits in the interior shell of a building. The methods for achieving the above are based on the following passive techniques:

- Thermo – insulation of the external walls and windows of the building
- Thermo – insulation of the roof of the building
- Thermo – insulation of the floor of the building

3.2.5 Maintaining heat by thermo – insulation of the external walls and windows of the building

The insulation of external walls is succeeded by using materials with pores (thermo – insulating bricks, monoblocks) with a small factor of thermal conductivity or by using conventional building materials combined with an insulation layer (fiberglass). Another solution is the construction of a wall comprising of two layers of thermal mass with insulation and air layers in between. Reducing thermal loss through windows is achieved by using thermo – insulating glass – panels, some of, which change their penetration quality according to the applied electric field or the level of lighting [5].

3.2.6 Heat maintenance by the thermo – insulation of the roof of the building

The thermo – insulation of the roof is similar to that of the external walls. Passive insulation (expulsioning polystyrene, fiberglass, insulation with metal fibbers and for the roofs with tiles: recycled paper, cork, cotton) is placed in the external side or between two layers of concrete [5].

3.2.7 Heat maintenance by thermo-insulaton of the floor of the building

The thermo-insulation of the floor depends on whether there is contact with the ground (i.e. no need for insulation), or with a non-heated space or with the external space (the thermo-insulation layer is placed in the external side of the thermal mass) [5].

Using passive systems in a building, like the ones already described enables it to cover a significant part of its thermal needs. The percentage of saving energy according to the building ranges from 17 to 48%. The use of double-glazing is possible to minimise the need for heating up to 7% while an increase in the efficiency of the thermal system per 10% can save energy up to 17% [5].

3.3 Cooling strategies

During the thermal periods of the year in mild climates like the Greek one, intense solar radiation (immediate and recycled) on the surfaces of the building, the penetration of thermal air, as well as the use of numerous electrical appliances may cause thermal increase in levels that many times greatly exceed thermal comfort [11]. Installing air-conditioning in Greek mega-cities is a common solution. However, this solution involves big consumption of conventional energy with great environmental consequences. Another way to avoid excessive heat is the application of passive cooling techniques in the building always according to the principles of bio-climatic architecture. Passive cooling takes advantage of both the building and the surrounding space and is succeeded in the following ways:

- Appropriate adjustment of thermal profits
- Reduction of the transmission of heat towards the building and
- Securing immediate thermal losses

3.3.1 Adjustment of thermal profits

Some of the most acceptable methods for protecting the building from undesirable thermal "profits" are described below.

A. *Shaping external spaces*

The external space of a building is a combination of natural and technical elements. More specifically, vegetation reduces air temperature and the temperature of the building surface [5]. Water surfaces like fountains and water tanks act like cooling sources except in cases of damp weather.

B. *Sunprotection*

The use of awnings or mobile tents is required especially for the shading of the south parts of the building where openings are wide and use of trees is ineffective [13].

C. *Controlling interior loads*

Minimising heat from interior loads is succeeded by replacing artificial light with natural, by choosing electrical appliances with small electrical loss and by reducing the activity of the residents.

3.3.2 Minimising heat transmission to the building

Reducing the incoming heat in a building is related to the thermo-capacity of the passive elements of the shell and its ability to store this heat. The use of passive elements of big inertia relative to the transmission and emission of heat in interior spaces in combination with the appropriate airing conditions aids the reduction of heat.

3.3.3 Minimizing thermal losses

Remaining heat in a building can be conducted by applying the necessary techniques, like the ones presented below. Airing demands of the interior spaces in Greece are regulated by the use of technical direction issued by the Technical Chamber of Greece [13].

A. *Conducting heat through natural airing*

Natural airing not only contributes to the reduction of temperature but also to maintaining the quality of the air (increase in oxygen levels and removal of odour and pollutants). Providing the necessary natural airing depends on the orientation, position and the size of the openings. Studies have shown that the air can be renewed by 30 times per hour through open window [13] while the maximum internal temperatures can be reduced up to 3^{o}C according to the thermal mass of the building and the quality of the air [5].

B. *Cooling through evaporation*

Cooling through evaporation is achieved by surfaces of stable or recycled water like tanks, swimming pools, fountains etc. round the building.

C. *Cooling through the ground (Passiving Cooling)*

The ground appears to have lower temperatures than those of the atmosphere do during summer months. Conducting heat towards the ground is succeeded in two ways [13]:

- Through the flow of heat from the building to the ground
- By using alternative heat ground-air

D. *Cooling through radiation towards the space*

Lowering the temperature of a building can be managed by emitting big-range wavelengths of radiation (thermal radiation) from the building to the space. In this way the temperature of the shell of the building drops, increasing the loss of heat from the interior parts.

As derived from data issued by the Ministry of Urban Planning and Public Works, improving the sun-protection of a building can secure the average reduction of the “cooling load” of the building up to 30%. Roof fans allow saving energy up to 70%, while the use of night airing reduces the “cooling load” from 40% to 80% depending on the kind of the building. Finally, by the use of additional cooling techniques, direct or indirect, the total coverage of the cooling needs of the building can be managed [5].

3.3.4 Strategies providing natural lighting

Sunlight during the day is direct and plentiful. Plenty of sunlight reaches the final receiver after being reflected on water and floating particles of the atmosphere. The ground also reflects the light that falls onto a surface.

Interior design (size – position of openings, inner wall distances) greatly determines the possibilities for the exploitation of natural light and its distribution to the buildings. Making the most of natural light can be achieved in various ways like the use of sloping – roof, multiple roof openings, vertical dormer – windows, lighting pipes (pipes of great reflecting capacity which directs sun-rays to the desired spot), atrium and “bright shelves” (horizontal reflecting surfaces directing light to inner spaces) [5].

The minimum required quantity of natural light for any space is determined by International standards. The Commission International de l’Eclairage (CIE) standards are prevalent in all European countries, while amounts of light are specified by the Natural Light Factor. This factor is the quotient of the amount of light on a certain spot to the relevant amount of lighting in an outdoors horizontal surface. The average factor in Greece varies from 0,7 to 3,5 according to the use of space [10].

A wide variety of research projects have shown that the greatest percentages of the annual energy consumption in Athens, are consumed firstly by cooling during the summer months, and secondly, by lighting and heating [14]. The global consumption of electrical energy was 12 trillion kWh in 1996 in the domestic section. As estimated, it is bound to exceed the 20 trillion kWh by the year 2020. The electrical energy consumption in Greece has increased by an average degree of 4% in the past few years [15]. It has also been estimated that the proper use of natural light leads to saving electrical energy from 10 to 60% [5].

4 DEVELOPMENTS IN GREEK BIO-CLIMATIC BUILDING DESIGN

The combination of the Greek latitude and plentiful sunlight results to daily sunlight rates of 4,3 kWh of solar energy per square meter of horizontal surfaces. Thus, the design of the buildings, based on the principles of bioclimatic design, in combination with the use of the necessary passive systems can lead to a decrease in the energy consumed for heating which can range from 40 to 60% in cold regions, reaching a 90% in warm regions [16].

The first applications of bio-climatic design in modern architecture in Greece date back to the 80's. Those first bio-climatic buildings of the period were few and mainly belonged to architects who constructed them in an attempt for more quality in design and derived from high ecological sensitivity.

In the years to follow, numerous bio-climatic buildings appeared mainly in Athens, Thessaloniki and Creta. Those buildings were the result of initiatives taken by various research and government centers, with most important the Greek Corporation for Solar Energy, the Institute of Solar Techniques of the University of Thessaloniki, the Department of Architect Engineering of N.T.U.A. and the Center of Renewable Energy Resources.

Various obstacles got in the way of attempts made for the expansion of ecological architecture for many years. The application of bio-climatic design and "clean" building technologies has been in the past few years, the basic axon of the national policy for environmental protection and the reduction of CO_2 emissions. The starting – point of all action schemes was the E.U. and National Programs which aimed at the saving of energy through appropriate techniques supported by the use of Recycled Energy Resources (R.E.R.) in buildings and generally in urban areas in Greece [11].

Photo 1: Central Buildings of the Administration of the Public Petrol Corporation "Hellinika Petrelea", in Aspropirgos, Attica.

The direct result of the above measures is that they have been successfully applied at the Solar Village with great energy benefits. The Solar Village is a complex of 435 homes constructed in 1988 in Likovrissi (construction architect Al. Tobassis) of Attica with the co-operation of the Greek Ministry of Development, the Workers Housing Organisation and the German Ministry of Research and Development. The agreement included the experimental application of energetic and passive systems of high technology. This settlement was carefully designed aiming at the best results possible as far as the thermal comfort was concerned in combination with low energy consumption [17]. All new public buildings (see photo 1) are designed and constructed based on the new legislative frame for the rational exploitation of energy including numerous passive structural systems in their architecture. The re-construction of an old industrial building into a prototype "Ecological Building" for housing the central offices and the organisations of the Ministry of Urban Planning and Public Works in the area of Eleonas.

Moreover, two new public buildings of high-energy efficiency are being completed in Thiva and Menemeni while various old blocks of flats housing refugees are being re-constructed by using environmentally friendly technologies. A great number of individuals have started using autonomous energy constructions for private use. A big part of these bio-climatic buildings (see photo 2) with obvious results in saving energy by using passive systems has been widely advertised in numerous Greek magazines and newspapers in the past few years [18]. In the same time, there are buildings which use geo-thermic and aeolic energy which however are still in experimental stage and have not yet become popular.

The design of a modern bio-climatic building demands through scientific research and technologies that require the co-operation of various specialists. The application of theory today is achieved by the use of the appropriate programs – packages. The most popular PC program of architectural – urban planning design in Greece is the Climate Responsive Computer Aided Design (CRESCAD) which takes micro-climate conditions into account providing in this way the possibilities for bio-climatic and energy settlements and building design. More specifically, it aids the researcher to evaluate design results by using specific sub-programs such as the

Shadowpack – PC (Sun and Shadows in Buildings), the Phoenichs – CFD (Air movement in the space) and the Suncode – PC (Thermal Behaviour of Buildings) [16].

Photo 2: ABB private corporation building in Metamorphossi of Attika

5 LEGISLATIVE MEASURES AND POLICIES TOWARDS A SUSTAINABLE GREEK CITY

Nowadays, there is a tendency to blame the urban phenomenon for the downgrading of the quality of life in big Greek and European cities. However, as stated by Jr. Miller, "the problem is not urbanisation but our inability to create sustainable cities so as to financially support the province" [1]. Various attempts have been made for adopting sustainable behavior of European cities in the last decades.

A significant step to this direction is the publication of the Green Bible for the Urban Environment in 1990 and the White Bible for the European Architecture of tomorrow in 1991. These give the basic directions for urban planning and architectural design focusing at the same time on respecting the environment and the saving of energy [19].

A very important guide for ecological design is the Green Vitrouvious, which was presented in 1999 by the E.U. Board of Architects. As far as bio-climatic design is concerned, it focuses on subjects like: the suitable position of a building so as to exploit the special characteristics of a place, avoiding the application of complex constructions, and predicting the energy behaviour of a building. The Green Vitrouvious also highlights the need for the co-operation of architects with consultants of other specialties (electricians, plumbers, technicians, etc.) in every step of the design and construction of a building so as to achieve the best possible solutions in financial and environmental level [19].

What is considered highly important in the domestic section is consumption and production of energy using renewable resources of energy (R.E.R.) as much as possible. The import of photovoltaic cells in the Mediterranean region is continually increased for the combined production of energy for heating and hot water is continually increasing. The Danish action scheme "Energy 2000" includes limitations of the rate of 15% in the consumption of energy, more than 40% in the consumption of fossil fuels for the production of energy and finally the radical reduction of CO_2 emissions [20].

In Greece, the relative legislative measures are taken by the Law 2244/1994 concerning issues of the production of electrical energy from RER, from conventional fuels and other issues. Based on the above law, a new field for the promotion of R.E.R. was created by the Greek State. The Ministerial Decision 8295/1995 and the Laws 2601/1998 and 2773/1999 followed, leading to the freeing of the production of electricity by R.E.R., either by individual producers or independent producers by putting an end to bureaucracy which interfered in the expansion of R.E.R. in the past.

Additionally, the Greek program for Climate Transformation encourages measures taken for saving energy and the use of R.E.R. in transport, industry, domestic and trades buildings and generally the Tertiary sector of production. This program aims at stabilising and limiting greenhouse emissions. The scheme focuses on measures concerning buildings by giving motives for the application of the article 6 of the Law 1512/85 at the same time combining Greek legislation and the community directive SAVE 93/76/E.C.C.

(stabilising and limiting CO_2 emissions by improving the energy efficiency of the buildings) [3, 21]. This decision regulates issues like the following:

- Manufacturing techniques of new buildings and urban regions for the best energy efficiency of existing buildings
- Taking steps for the improvement of the energy efficiency of existing buildings
- Boosting bio-climate architecture and ecological construction by using "clean" technologies for the saving of natural resources, recycling domestic waste and offering appropriate heating and quality of interior air.

In this frame the action scheme "Energy 2001" was initiated by the Ministry of Urban Planning and Public Works in the beginning of 1996. This was directed by teams of specialists and representatives of branch scientific authorities aiming at the application of systems and techniques, which contribute, to the saving of energy in the domestic sector [22]. In other words, "Energy 2001", specialises the Greek program for climate transformation including measures and motives for "Sustainable Buildings" and "Sustainable Cities", like [19]:

Interference in the shell and settlements concerning heating, cooling and lighting for the improvement of the energy efficiency of the building, by giving legislative, administrative and financial motives.

Special interventions in traditional buildings and generally domestic areas incorporated in their special characteristics.

Obligatory measures for the energy management and efficiency of the total of public buildings and buildings of the wider public sector in general.

Bio-climatic energy design for all new buildings and general domestic areas.

Eventhough passive systems have been applied for decades in European countries, only recently have they been included in the Greek legislation by the General Building Regulation (G.B.R.). This aims at saving energy in the building sector and promotes the sustainable design of buildings. More specifically, the new G.B.R., Regulations of Thermo-insulation are replaced by the Regulations of Rational. Use and Saving Energy. According to the new Regulation, new buildings should consume the minimum energy possible with high environmental efficiency [23] so as to succeed the following:

- The wide exploitation of natural energy and local climate conditions so as to minimise the energy needs of the buildings (bio-climatic architecture).
- The covering of the thermal demands of the shell and the efficiency of the electro-mechanic installations.
- Satisfactory levels of thermal comfort throughout the year.
- Sufficient natural lighting and airing.
- Quality of interior air.
- Consumption of energy according to the building category within limits.
- Energy supervisions and energy – environmental certifications of the buildings and
- Energy Identity Card.

This Energy Identity Card should accompany the building license enabling the users to know the quality characteristics of the building and generally the conditions of the buildings in the country. Based on the Regulations of Rational Use and Saving of Energy, all buildings should have an Energy Identity Card from 2006 and on.

6 ENERGY PROGRAMS FUNDED BY THE E.U. AND NATIONAL PROGRAMS FOR THE USE AND EXPLOITATION OF SOLAR SYSTEMS

Most of the following sub-paragraphs presented occupy with suggestions-actions aiding the wider expansion of R.E.R.

6.1 Operational Energy Program

The operational energy program of the Ministry of Development had a 5-year duration (1994-1999) was included in the European Community Supporting Fund Program and consisted of four semi-programs. This program promoted and funded the use of R.E.R. in the private financial sector by incorporating actions relative to saving energy in buildings of the trade and the general tertiary sector. Among investments made, 92 were of central solar, photovoltaic and passive energy systems of a total budget of 26.7 million euro [24].

6.2 - The SAVE program

The SAVE program has been in action from 1991 to 1995 and was replaced by SAVE II in action from 1996 to the end of 2000. This program was of non-terminal character aiming at the rational use of energy aiding the efforts of the E.U. country members for energy saving. The target was to create a suitable environment for accelerating relevant investments. The expanded program SAVE II provided special actions aiming at the improvement of energy management in local and regional level paying particular attention to promoting modern photo-voltaic systems. Briefing activities included events and conferences in national and European level, as well as the relevant publications organized by the European Energy Net (EnR) [25].

6.3 - The ALTENER program

The ALTENER program is a program of the General Administration XVII of the Community for the energy. It has non-technological character. The sub-program ALTENER II is the continuation of the ALTENER I (1998-1999). ALTENER contributes to the adaptation and materialization of the aims of the White Bible. The aim of this program is to triple the production of electricity from RER by 2010, by providing new motives for the increase of private investments and the reduction of CO_2 emissions by 180 million tones. In Greece, new directives were given based on ALTENER II for investments in energy solar systems by the National Technical University of Athens (N.T.U.A.) and CRRE, especially for the island of Crete [26].

6.4 - The SYNERGY program

SYNERGY (1998-2002) is a program of the General Administration XVII of the Community with the basic aim to promote co-operations in the section of Energy, emphasizing especially on the R.E.R. development while 12 million euro have been given for this reason [25].

6.5 - The COMPETITIVENESS program

The "COMPETITIVENESS" program of the Ministry of Development is included in the European Community Program No. III (2000-2006) and is concerned with financial motivation given for individual investments of Saving / Co-production / Substitution and R.E.R. in the areas of the inter-connected system of the country. It also deals with investments with power more than 5 MW in the areas that are not within the inter-connected system. Suggested investments for the development of passive systems can reach a subsidy of 40% of the total budget of the entire country.

7 BENEFITS AND MOTIVES FOR THE SAVING OF ENERGY BY THE USE OF BIOCLIMATIC TECHNIQUES

The already mentioned policies and programs aim at the maximum exploitation of solar and aeolic energy in the ecological design of buildings based on the use of passive systems. At the same time they contribute to the de-centralization of energy production and towards regional development.

The predicted benefits from the application of especially the program "Energy 2001", which particularly promotes bio-climatic design, are significant especially in social, financial and environmental level. New demands in the design and construction of high environmental and energy efficiency buildings will shape new conditions in the market since there is an increased demand for quality construction products. It is also predicted that novel attitudes and perceptions will be formed leading to a gradual alternation in production and consumption standards not only in energy but in other sectors as well.

The immediate results of the above changes will, in all probability, be obvious in occupation level by the creation of new positions both in the industrial and the construction section. A significant increase of competitiveness has also been foreseen in the field of R.E.R. and generally of "clean" building technologies. As a result the quality of constructions is improved as well as living conditions within the buildings of mega-cities and settlements of the country.

Furthermore the re-enforcement of the national financial economy and the saving of energy and natural resources generally is predicted with the parallel boost in construction activities. The observance and the application of the above suggested measures demand for more than the suggested policies and laws. Co-ordinate efforts towards the basic action frames are extremely essential [22]:

- Raising public awareness on environmental issues and professional training
- Supporting co-operations among social authorities, Local Administration Organisations, Business and Professional Unions, Research Centers, Universities and Technical Colleges, Ecological Organisations and other Non-Profitable Private Organisations.
- Pilot applications in buildings, in regional building constructions, of high environment and energy efficiency.
- Establishing surveillance mechanisms through regular supervisions for the energy certification – rating and application of the required regulations for the installation of energy equipment not only of buildings but of energy consuming businesses as well.
- Tax exemption and funding for the purchase of "efficient" buildings and electrical appliances with the simultaneous increase in the taxation of the use of petrol and generally conventional electrical energy.
- Creation of a legislative frame for the composition of a bio-climate study, and finally
- Encouragement for the research of non-polluting innovative technologies which will give a boost to the social and ecological reality.

8 CONCLUSIONS

Bio-climatic design uses R.E.R., limits the consumption of conventional fuels to a minimum and avoids the use of air-conditioning for the cooling and heating of the buildings. A bio-climatic building offers a healthy environment from a physiological and social aspect with the fewer environmental consequences possible. A new kind of building is created which uses natural sources in a rational way, securing the best possible living conditions, enhancing at the same time the positive "interaction" between the building, the urban space and the natural environment. Consequently, bioclimatic rationale aims at saving energy up to 60% by contributing to atmospheric and generally environmental protection.

The application of bio-climatic design in Greece offers great possibilities that do not oppose to traditional building techniques. The mild Greek weather conditions gives the opportunity for the application of bio-climatic design.

Bio-climatic architecture can be applied in any building with reasonable expenditure. Even when there is an increase in the construction cost, this rarely exceeds a 10% in the total budget. Such an increase is also attributed to extra insulation or to the installation of roof-fans or other relative elements. Increased cost is depreciated by the limited use of conventional heating and air-conditioning units. Buildings designed according to bio-climatic principles offer a pleasant environment and save energy at the same time.

The energy crisis of the past few years had obvious financial consequences, which led to radical changes in the wider policy for the management and use of R.E.R.. Bio-climatic buildings have an advantage over conventional ones as they offer the chance for the reduction of energy needs in the building section. In order to succeed sustainable development R.E.R. and especially solar energy should be fully exploited. The amount of solar radiation is estimated to be 25.000 tones bigger than the total global consumption of energy.

Bio-climatic architecture promotes numerous social and non-financial values like a sense of ecological responsibility, the realization of the exhaustion of natural resources and the pleasures of natural life.

Modern bio-climatic design can and should become the architectural expression of a "wiser" consideration of the society and the environment, focusing on the common "man" with his traditions and values.

At this point, the principles of bio-climatic architecture should be mentioned relative to the reshaping of historic centers, traditional settlements and individual renovations of important buildings. Eventhough, traditional architecture followed natural patterns and can be considered bio-climatic in itself, it is however necessary to systematically research the application of modern bio-climatic architecture design when reshaping a building so as to adapt it to contemporary needs.

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