SUSTAINABLE CONSTRUCTION IN GREECE - NATIONAL REPORT

1.0 INTRODUCTION

The following report is constructed for the **C**ouncil for **B**uilding **R**esearch studies and documentation - **CIB** - and reflects mainly the views of the authors, **Dr. Dimitris Bikas** (Associate Professor) and **Mr. Sotiris Milonas** (Civil Engineer), who joined the W82 (Future studies in Construction) project for the Greek part.

The information presented is selected from Government papers, University and other academic sources or activities and through personal research. The selection and the reporting of the data is prototype for Greece and many changes will occur in the following years.

2.0 GENERAL DATA ABOUT GREECE

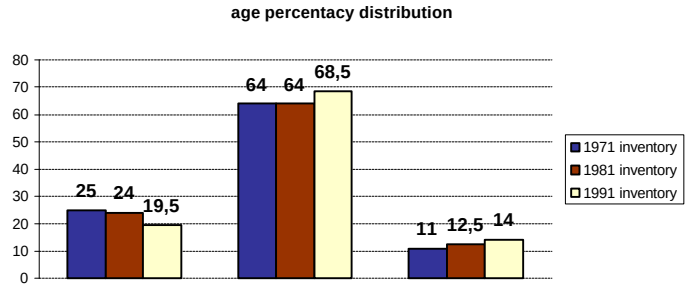
- Greece is located in the southeast part of Europe and has a total surface area of 131.944 km^2. The 106.777,76 km^2 are main land and 25.166,24 km^2 are islands. Coastline length is 15.021 km.
- The population is 10.454.019 (1995) which is not normal distributed (62% is urban population and 38% is rural population.)
- The capital city of Greece is Athens, which is also the largest city. Thessaloniki is the second largest city of Greece. Other major cities are Patra, Kavala etc.
- The climate of Greece is considered as mediterranean.(300 sunny days, an average wind speed 7,5 m/sec in islands)
- Greece is located in a strongly seismic zone.

3.0 CONSTRAINTS, SPECIFIC ISSUES AND FUTURE SCENARIOS

The following issues could characterise national features:

3.1 Economic and social Constraints

- Illegal immigration and refugees
- Low birth-rate
- Increase of life expectancy, high portion of aged people as chart indicates



set of columns present ages

- under 15
- between 15-64
- over 65

- Urbanisation of rural areas
- High levels of unemployment for women in rurban and rural areas.
- Increasing rate of investments by the public and private sector and high availability of public investments funds.

3.2 Environmental constraints and government policy

3.2.1 General

The environmental program of Greece for the following years aims at addressing the major environmental problems as well as at creating the infrastructures for the efficient management of the Greek environment in the 21st century. National and community funding support the ***O**peration **E**nvironmental **P**rogram* of Greece. The legal framework of OEP are the National law 1650/86 for the protection of the environment, the EC environmental regulation and directives and the obligations of Greece with respect to International environmental Agreement and Conventions. OEP is based upon the sustainable principle as it aims at improving or protecting the environmental conditions in Greece, while at the same time preserving the development efforts in the industrial, tourist and agricultural sectors.

Greece is also following the ratification of the Summit's resolutions in April 1994 in the United Nations Framework Convention on Climate Change with the following obligations:

- The elaboration of a detailed inventory of greenhouse gas emissions and the monitoring of their evolutions, and
- The formulation of a program for the stabilization and reduction of emissions in the following years and the monitoring of its implementation.

The Greek Program for the reduction of CO_2 and other greenhouse gases was elaborated under the responsibility and supervision of the Ministry for the Environment, Physical Planning and Public Works, in collaboration with the Ministry of Industry, Energy and Technology.

3.2.2 Data concerning energy consumption and environmental releases.

- Energy production and consumption in Greece account for 88 per cent of all greenhouse gas emissions and for as much as 98 per cent of the CO_2 released into the atmosphere.
- The demand for energy in Greece registered an important increase throughout the last years. (This increase in energy demand, led to an increase in the supply of electricity)
- The increase in energy demand was not uniform in all sectors. (The increased rates recorded in the domestic and particularly in the transport sector were much greater in comparison to the other sectors.)
- The increase in CO_2 emissions was much sharper than the respective growth rates of the Greek economy and of the national energy demand.
- The evolution of CO_2 emissions in Greece throughout the 1970-1990 period marked by a drastic increase from 22 to 82 million tones.
- When the contribution of power generation is distributed to the final energy users, it appears that the domestic-commercial-services sector registered the sharpest increase in CO_2 emissions and the highest global (direct and indirect) participation in 1990. (Rising from roughly 32% in 1970 to 39% in 1990).
- The emissions of the industrial sector increased in absolute numbers and their proportional contribution to the global emissions of CO_2 actually decreased (from approximately 46% 1970 to 41% in 1990). The relative contribution of transports to the emissions of CO_2 remained stable (at around 20%).

The table summarizes the Greek Primary Energy Demand (Source Greek Ministry of Energy)

Source	*Year 1999 (Mtoe)*	*Percentage (%)*
Lignite	8,91	36,4
Coal	0,73	3,0
Hydro	1,67	6,8
Natural gas	2,65	10,8
Crude oil	10,54	43,0
Total Primary Energy	24,5	100

3.2.3 Greek national policy for "sustainable development"

In order to attain sustainable development Greece is focusing on the following targets

- Integration of Environmental and Economy. Incorporation of the principles, values, sensitivities and priorities of ecology in sustainable development.
- Balanced socio-economic development, reduction of differences between the so-called "developed" and "problematic" regions or between centre and periphery.
- Decentralization of activities and population
- Improvement of development potentials of peripheral regions and survival of small towns and rural centers
- Mitigation and reversion of the trends of migration and urbanization
- Preparation of the national cadastre
- Reinforcement of the economic, social and cultural development of remote areas.
- Resharpement of the total government services and responsibilities
- Energy planning towards renewable sources.
- Enhancement of the social cohesion and the environmental and cultural identity of urban centers and minor settlements.
- Conservation of the balance harmony and diversity of the Greek nature and ecosystems
- Rational and integrated management, control and protection of water resources.
- Abatement of coastal and marine pollution.
- Improvement of the urban environment and living conditions (atmospheric and noise pollution in large urban centers, integrated and national waste management)
- Mitigation of unemployment problems and improvement of working and safety conditions.
- Education training and awareness raising for sustainable living patterns
- Promotion of international cooperation and implementation of international conventions.
- Enhancement of the participation of major groups.

3.2.4 The energy program

3.2.4.1 Operation Program for Energy

The general objective of the program is to support projects necessary to meet energy demand, to support rational use of energy and to promote the wider exploitation of renewable energy and other local energy resources. In addition the program reflects the commitment as well as the efforts of the Greek Government to link development to environment, in manner which will support the uninterrupted implementation of the development policy of Greece, while at the same time safeguarding the environment and the physical resources.

The foreseen activities are expected to motivate the energy market and to have a substantial impact on National Economy. The total budget is 946.305 KECU of which 37,2% is the Community support, 29,7% National support and 33,1% private contribution.

The Program's initiative for energy saving is probably the first systematic effort in promoting energy methods and technologies. The annual energy savings, as a result of the application of the program, are estimated at 5% of total national energy consumption.

The penetration of Renewable Energy Sources (RES) and the development of the respective technologies are also an important objective of the program. Priority is given to wind energy, Hydropower, solar energy, biomass and geothermal energy. The expected investments are estimated to substitute 1.4% of total national energy consumption or approximately 200 ktoe, by the end of the century.

3.2.4.2 Renewable energy sources (RES) - Rational Use of Energy (RUE)

Greece possesses a significant Renewable Energy Sources potential. The development of RES and RUE has been set a national priority. Today three main axes define RES and RUE policies, towards the ultimate objectives of guaranteeing security of supply, reducing energy costs and protecting the environment.

The new legislative framework that seek to promote RES and RUE includes:

- The basic law 2244/94 which incorporates institutional regulations for co-generation and the establishment of a dynamic traffic policy for RES electricity production
- The development law 1892/92 which foresees the subsidization of industrial activities relative to energy saving and the subsidization of industries and companies for the production of electricity through the exploitation of indigenous RES
- The operation Program for Energy, where approximately 190 MECUs have been earmarked by the government for RES and RUE development programs (1994 - 1999)
- The Operation Program for Research and Technology, which supports among others RD&D activities, activities for RES and RUE sectors
- National financial mechanisms and programs
- The national use of the relevant EC/D GXVII energy programs (ALTENER, THERMIE and SAVE II)

The following aspects are worth noting for the development of RES

- Greece has the highest geothermal potential in Europe, which is equal to 750 MW. Technological problems including drilling, capacity, high silicate content of water are the main factors for the slow energy projects in Greece.
- With wind speed exceeding 7.5 meters/second and in some areas 9.0 meters/second, Greece has some of the prime wind areas in all of Europe.
- With mountains covering large portions of the mainland and some islands, Greece offers considerable potential for the development of micro-hydro power
- Good solar resources (5.3 to 6.5 KWH/square meter/day average)

The table quantifies the scenarios regarding the development of RES in the following years (power production)

Technology	*1998 values*	*2005 scenario*	*2010 scenario*
Wind power plants	39 MW	800-1000 MW	1500-2000 MW
Large hydroelectric	2784 MW	3100 MW	3250 MW
Small hydroelectric	42 MW	150-200 MW	300-400 MW
Photovoltaics	0,3 MW	30-40 MW	150-200 MW
Solar collectors	2300000 m^2	6500000-7000000 m^2	9000000-11000000m^2
Biomass	900 Ktoe	1600-1800 Ktoe	2300-2700 Ktoe
Geothermal	3 Ktoe	80-100 Ktoe	160-200 Ktoe

3.2.4.3 Natural gas

The introduction of natural gas into the Greek energy system is the most important structural change of the last two decades. Natural gas replaces mainly fuel oil in the industrial sector for process heating and diesel oil in the residential and tertiary sectors for central heating. A total gas quantity of 1,500 million Nm^3 per year will be committed for power generation. Of the total industrial natural gas consumption of 1.0 billion Nm^3 anticipated for the year 2000, approximately 80 per cent will be absorbed by a limited number of large industrial units, to judge from the negotiations currently in progress with potential clients.
Natural gas penetration will be slower in the other sectors and is not expected to exceed the 0.5 billion-m^3 level in the year 2000. This is basically attributed to the long time periods necessary for the construction of the distribution networks in residential areas and the inertia characteristic of current consumer behavior. The larger part of this natural gas will be used for space-heating purposes, as a substitute for diesel. Substitution for electricity (for cooking and water-heating purposes) will remain limited, since the significant expenses necessary to switch existing installations over to natural gas will only prove profitable in cases where the use of natural gas is substantially more energy efficient. The substitution of natural gas for electricity has, however, been envisaged in air-conditioning applications with the use of new types of equipment, mainly in the commercial and services sector. According to the program of the Public Gas Corporation, the secondary pipelines and city networks are to be completed by 2005, at which time the total absorption of natural gas will reach an estimated 3.5 billion Nm^3 per year (1.5 billion Nm^3 for electricity generation, 1.0 billion Nm^3 for industrial uses and 1.0 billion Nm^3 for the needs of the domestic and remaining sectors).
Natural gas integration into the Greek energy system will have positive impacts on the energy and economic systems as well as the environment. The benefits from the introduction of natural gas are expected to be as follows:

- Decrease of oil imports
- Decrease of lignite use
- Improvement of total energy efficiency
- Decrease of total energy efficiency
- Significant decrease of emissions of various pollutants (No_x, SO_2, CO, CO_2 and particulate)
- Increase of GDP during the construction and operational phase
- Creation of new jobs

3.2.4 Supply side interventions - Energy supply

As surprising as it may seem, 50 per cent of Greece's CO_2 emissions are caused by the production of electrical energy, since the national power generation system is based on the combustion of a thermally poor lignite. Consequently, the success of any policy for the abatement of CO_2 emissions will largely depend upon decisions affecting the power generation sector.

- **The modernization of the existing system** - so as to improve the efficiency of the lignite-fired stations, to reduce the losses in the transmission and distribution system, and to introduce new and "cleaner" lignite combustion technologies will have a very favorable impact and therefore constitutes one of the national program's fundamental objectives.

- **The development of combined heat and power generation systems** (with an energy efficiency of 80-85 per cent in comparison with the 30-35 per cent level reached in conventional plants) will be supported both legally and financially.

- The use of **natural gas** for electricity generation **The completion of the central pipeline** ramifications will accelerate the penetration of natural gas in the industrial sector.

- The extensive use of **renewable energy sources** is also expected to make a marked contribution to the abatement of CO_2 emissions.

3.2.5 Demand side interventions

Even though the CO_2 problem in Greece is basically a "supply side" issue, energy conservation nevertheless constitutes an immediate priority, which can substantially improve the system's energy and economic efficiency and reduce the emissions of CO_2 (and other greenhouse gases). In all sectors of activity, there are still numerous possibilities for profitable investments in technologies and/or products, which contribute decisively to energy conservation. Previously acquired experience will serve as an additional asset and ensure the greater effectiveness of the adopted measures and elaborated policies.

In the **domestic-commercial and public sectors**, the energy conservation measures essentially involve

(a) The **reduction of energy requirements**, by incorporating *"passive systems"* in new buildings, by increasing insulation requirements in new constructions and improving the situation in the existing building reserve.(According to 93/76/EEC - L 37/28/22.9.93)

(b) The **rational use of all available energy sources** with the introduction of new fuels and primarily of natural gas and

(c) The **introduction of new technologies** (increased efficiency equipment and appliances) and the proper maintenance of existing ones.

An essential element is the creation of a market of services and intermediaries between the controlling authorities and the vast number of decision-makers and consumers. This includes:

(a) The elaboration and monitoring of energy balances in the SMEs and large buildings;

(b) The certification of proper operation and the detection of necessary adjustments or corrections to be made; and

(c) The regular maintenance of boilers, engines and other equipment require services from numerous fields of specialization, from energy engineers to specialized technicians.

The realization of all of these interventions is expected to lead to a considerable reduction in the emissions of CO_2. *This reduction will also come from the penetration of natural gas in such areas as space/water heating and even air-conditioning, and from the extensive use of solar geysers.*

In the industrial sector as well, the introduction of natural gas constitutes the most effective CO_2 abatement measure. Other previously mentioned measures, such as the reinforcement of "new technology" solar systems and the promotion of cogeneration - although indubitably beneficial - will have a less tangible impact.

A wide range of what are usually considered "minor improvements' can be made in the auxiliary operations of industrial units. The most important of these interventions involve the supply of steam and compressed air or even the lighting of industrial premises. Other measures, such as the improvement of space/water heating, are expected to have a smaller impact.

There are also numerous technological interventions, which can be carried out in the production procedure of all of the industrial sectors. The industries which present the greatest abatement potential are, of course, the more energy-consuming ones, such as: the *cement industry, metallurgy (steel and non-ferrous metals),* fertilizers and the sugar industry.

The possible interventions for reducing the CO_2 emissions caused by **the transport sector** can be either direct or indirect in nature. The first category includes measures targeted in priority at restricting CO_2 emissions. In the indirect measure group, the reduction in emissions, on the contrary, results from the pursuit of other objectives, mainly related to the improvement of transport services. Whatever the case, the CO_2 abatement measures do not, by any means, worsen the already poor quality of transport services.

The **direct measures** focus either on:

(a) The fuel types in use, through the promotion of more effective fuels (diesel) and the use of biofuels (primarily after the year 2000) that do not burden the atmosphere with CO_2 emissions, or on

(b) The vehicles in circulation, through the promotion, for example, of their systematic maintenance and the use of more economical models.

The **indirect measures** involve either:

(a) The rational management of the entire transport system (improved road network and signaling, restructuring and combined use of transport modes, changes in driver mentality and behavior), or

(b) The modernization of public transports for the large cities, which continue to provide particularly poor quality services (metro, tram, improvements in urban bus routes, etc).

Many large "transportation construction" projects are being under construction or will commence in the current year. These include highway projects, bridge constructions, the railway modernization, the expansion and modernization of ports, the new Athens Spata airport, Athens and Thessaloniki subway and some other networks servicing Olympic Games 2004.

An important aspect to mention is that all transportation construction projects can be completed only after the approval of the environmental impact assessment study. Environmental studies are a basic law in Greece for all kinds of constructions that may have an impact to ecosystems and local environment. The structure of environmental studies is standard depending on the type of construction work.

4.0 WASTE MANAGEMENT

At the national level, technical specifications for the safe handling of waste are being determined. A system of permits was introduced for the collection and transport of solid waste. Legislation has been issued aimed at reducing air pollution from waste incineration plants. Threshold limits have been established for heavy metals in sewage sludge used in agriculture. In accordance with EU Directive 91/156 the establishment of an integrated network of waste disposal is being planned. Activities were initiated to promote waste prevention and recycling. Recycling programs are being implemented for paper, glass and aluminum. Programs are being introduced for the reduction of weight and volume of packaging material. Awareness campaigns are being carried out. Responsibilities for waste management have been delegated to local authorities. The management of liquid wastes is

focused on the treatment of liquid wastes at the national scale with the construction of waste treatment facilities in settlements larger than 15,000 inhabitants.

Specific Actions

- Development of national management scheme for urban and industrial liquid wastes
- Development of support Centers for the Operation of Waste Treatment Facilities
- Construction of waste Treatment facilities in sensitive regions
- Implementation of innovative and adjusted technologies for the treatment of urban liquid wastes in selected areas, reuse of treatment wastes.
- Construction of facilities for the treatment of industrial wastes.
- Program for the integration of clean technologies in industrial practices
- Program for the recycling of industrial waste

One of the major environment problems of Greece is the management (collection, treatment, disposal) of solid and toxic wastes. Greece is promoting the needed actions for the implementation of the new directive for the Landfills, and gives considerable weight to the cleaning of coastal areas and swimming sites.

5.0 DEFINITION

The official definition of "**sustainable development"** is *that type of development which meets the present needs without endangering the capacity of the future generations to meets their own needs.*

Other official definitions include the term of "**natural ecology"**, which *is a system that maintains its equilibrium by circulating resources and wastes internally* and the term "**quality of life"** which, is *a composed of several aspects including material living standards, public health and safety, health care, fulfilling occupations, opportunities for personal development and advancement, community, culture, social life and recreation, environmental amenities and aesthetic qualities.*

However there are no official definitions of the following terms so we accept the existing ones of other researchers and organizations. Sustainable construction, built environment, urban sustainable development, sustainable environment are some definitions that should be adopted from the building construction industry.

6.0 GENERAL DATA ABOUT BUILDING CONSTRUCTION

6.1 Greek Building Industry

With the term **"building industry"** we mean all the sectors (from engineers to manufacturers and market) which are related to building construction. The construction industry is a major constituent of the Greek economy. It is an established sector and well geared to local conditions. The construction industry is divided in three main categories: residential, commercial, and public works.

The Greek market for building materials and products is around 4,2 billion USD. Imports mainly for the European Union is about 27% of the market. Local production covers the market need extensively. Over 70 percent of Greece's industry are located in the country's four major cities. Exports by local manufactures, estimated at 20 million USD, excluding cement exports which are really high.

In **terms of employment**, construction is a labor-intensive industry, particularly in its final assembly stage on site. Traditional the industry (specially the construction part) has absorbed large numbers of poor qualified labor from the lowest strata of educational achievement, and new refugees (because of lower wages). For improving employment conditions it is important to improve education and training in all levels. The building material production sector employs around 25000 people. Approximately 1400 commercial enterprises deal with the importation, supply and distribution of building products and materials. The Technical Chamber of Greece has 46000 members composed of architects, civil, mechanical, and electrical engineers.

The production of building materials in Greece uses mainly locally raw materials, which can be found, throughout the country (local markets). This results in low consumption of energy for transportation (20-30km for distribution). The production processes are based on the combustion of fossil fuels and on electrical power.

Sustainable development and its adoption in the construction industry will improve the quality and environmental requirements as well as economic consequences. To achieve this goal a series of strategic objectives and recommendations should be analysed and set and finally establish a programme to follow up these. In consideration with the increasing rate of building construction the above have to be strongly and well organised.

The sector generates an enormous quantity of construction **waste** and demolition materials and only a small part is recycled or reused. The other part ends to disposal sites, which are organised from local authorities. (The amount is approximately calculated to be 500kg/person/year)

The necessity of proving greater **environmental protection** may in time lead to the need for more complex building design solutions. A proactive attitude both from the actors in the construction sector and from public authorities appears necessary to ensure the achievement of environmental objectives such as reducing the use of resources and energy, increasing re-use and recycling and achieving a proper disposal of waste. The impact of increased environmental awareness on construction enterprises is two fold. Firstly they will need to adopt to the additional constrains imposed on their activities. The better adopted a company the more likely it is to gain competitive advantage, using environmental friendly construction as a marketing tool. Secondly, the climate of environmental awareness and sustainable development will create new markets and new opportunities for those companies able to record to the changing demand of clients.

Greek government through a body corporate inspects all construction works in terms of environmental delinquency. The company is manned with qualified engineers and other scientists in order to audit the observance of national and EU legislation and standards in the following categories of construction works. Buildings are not included in the auditing system.

- Road construction and maintenance
- Port and other harbour constructions.
- Airport constructions
- Industry construction
- Hotels and their facilities
- Hydraulic works.
- Scrap disposal areas and their plants.
- Aquiculture
- Biological treatment of liquid waste plants.
- Other construction works

6.2 Construction practices

The construction materials that are commonly used in Greece for residential and office buildings are reinforced concrete for the structural framework and brick & mortar for internal and external walls. The composition of the plasters is basically a mixture of lime with cement, however recently synthetic ones are replacing them. The building elements of the envelope are insulated according to the Greek insulation standard. External walls usually, are double brick walls with core insulation. The external concrete building elements of the envelope (columns, beams, and structural walls) are equally insulated, and the roofs have an insulation layer plus a moisture control layer. The life span of this type of construction is over 80 years.

The following matrix table indicates the consumption of energy, water and admixtures in a typical Greek building construction.

CONSRTRUCTION ACTIVITIES	WATER CONSUMPTION	ADMIXURES	ENERGY
Digging	¨		¨
Drainage and prevention			¨
H&V transport	¨	¨	¨
Safety measures	¨	¨	¨
Formwork	¨	¨	
Connecting reinforcement			¨
Pouring concrete	¨	¨	¨
Vibrating concrete			¨
Controlling the hardening	¨	¨	¨
Curing, finishing	¨	¨	¨

6.3 Present situation

Greece has 3.821.175 buildings of all uses (1990 inventory - National statistic office). Residential building represents the *73,3* percent of the existing building stock. Another important statistic aspect concerns the age of the existing building stock where the *89,4%* are constructed before 1981 and only *6,7%* are constructed after. The above separation is important, as the reference year 1981 is when the enactment of Thermal insulation Regulation has been activated in building construction.

A classification of buildings according to the **number of storeys** shows the following.

- The majority buildings that are located in urban and suburban area have 4-8 floors.
- In rural areas buildings have 1-2 floors
- In a national basis the *64,4%* have 1-2 floors, while the remaining *35,6%* has more than 3 floors.

A classification of buildings in Greece according to **thermal quality** shows that.

- *30,4%* of the buildings have roof insulation
- *1,5%* have floor insulation
- *5,1%* have insulation on the external walls
- *2,1%* have double glazing
- *4,2%* have insulated distribution pipes

6.4 Energy consumption of buildings in Greece

The **energy consumption** in buildings is especially for heating, cooling and lighting purposes, while electrical appliances and office equipment also consume significant amount of energy. The application of energy saving techniques and the use of solar or other renewable energy in buildings requires the knowledge of their special characteristics. Some of the required information are the frequency distribution of the building, total energy consumption, the specific energy requirements per use and per purpose (heating, cooling, lighting e.t.c) and the specifications of the installed systems as well. A research project of Aristotle University of Thessaloniki has achieved to add extensive information in the above matters by auditing the energy performance of multi-use buildings in Greece.
This extensive survey that was performed during last years concerning the energy consumption of multi-use buildings, showed that the total energy consumption of buildings varies from 60-500 kWh/m^2 annually, depending on the type and uses of buildings. The annual consumed energy for the various purposes was found to be

- Between 30-170 kWh/m^2 for heating
- Between 15-90 kWh/m^2 for cooling
- Between 10-50 kWh/m^2 for lighting
- Between 10-80 kWh/m^2 for the operation of various appliances and equipment.

In the area of Thessaloniki (northern part of Greece) the values for the annual energy consumption varies from 375-156 kWh/m^2 depending on the type of the building (one kWh/m^2 mean approx. 1 lit of oil/m^2/year).

In terms of **embodied energy** the survey is not yet extensive and the following case study building which is representative for a common middle cost construction, constitutes 55-60 percent of its overall cost. The integrated building elements of the loadbearing structure represent 46 percent of the initial embodied energy, and if we include the roof, the percentage value rises to 56 percent. For the CO_2 equivalent emissions these values are correspondingly 60-68 percent and for the SO_2 equivalent emissions these values are correspondingly 38-52 percent of the entire building. Slabs are the dominant building element when compared with structural walls and beams. When we turn our attention to the non- structural walls, the internal walls represent three times greater amounts of the embodied energy in comparison with those of the external walls. For the CO_2 and SO_2 equivalent air emissions, these proportions are correspondingly 4.3 and 3.8 times greater when comparing internal and external walls. It is also useful to mention that the environmental attributes of building elements contained in the building envelope are less significant than the internal building elements. Embodied energy values are taken from international bibliography. (*total embodied energy 5.939 GJ - CO_2 equiv. 12.968,1 kg/year - SO_2 equiv. 36 kg/year*). Furthermore, for a life expectancy of 80 years and due to building element replacement cycles it is calculated that 72,7MJ/m^2year is required for the initial embodied energy which represents 10 percent of the energy consumption for heating the entire building when it is insulated and 28,4 when it is not.

6.5 Action Plan "ENERGY 2001" Energy Conservation & Promotion of Renewable Energy Sources in the Built Environment.

The Action Plan "Energy 2001" of the Ministry for the Environment is an Action Plan for Energy Conservation in the Built Environment concerns in the promotion of energy conscious building construction techniques and services and the integration of renewable energy technologies

The Greek National Policy for Environmental and Energy Efficiency in buildings for housing, commerce and public service at urban level is focused on strategy and activities to change production and consumption patterns, and to promote rational use and management of natural resources. This Action Plan specifies some objectives of the Greek Program on Climate Change and it is associated with the implementation of the European Directive SAVE 93/76/EE for the "stabilization of the CO_2 emissions and energy efficiency of buildings". Proposals concerning the application of new energy techniques for the exploitation of renewable energy sources, combined with incentives policy, energy auditing and an Eco-energy labeling system to certificate the energy efficiency of the buildings throughout the country, constitute the core issues of the project. Furthermore, specific proposals are made for listed buildings and settlements to preserve the architectural and cultural heritage and the traditional construction techniques and materials.

6.5.1 Objectives

- Implementation of some basic principles of the 5th Action Program of European Union for the Environment.
- Rational use and management of natural resources, use of renewable energy sources.
- Sustainable human settlement development (energy efficient).
- Solar bioclimatic architecture and planning.
- Eco-energy labeling system applying in all buildings.

6.5.2 Implementation

6.5.2.1 Activities

In order to monitor and evaluate the impact of energy saving measures, the Ministry of the Environment, Planning and Public Works is establishing a data bank. This facilitates the construction of an Environmental - Energy Map of cities and settlements in several climatic zones, with regard to different building sectors and assists the presentation of the actual situation as regards energy consumption and the related CO_2 emissions and evaluation of the impact of the proposed measures at different phases.

Priority has been given to the immediate implementation of energy saving measures in existing buildings, especially residential ones, and also in buildings constructed before the enactment of the Thermal Insulation Regulations (1981), which constitute by far the largest portion of the country's building stock. Otherwise priority to energy saving applications has been given to all buildings sheltering intensive activities, such as hospitals, schools etc. Other activities concern prices and incentives, which have already been given in several cases, in order to promote the application of sustainability principles.

Drastic interventions can also be carried out in the lighting sector. More specifically, the installation of sodium lamps could be rapidly advanced in the area of **public lighting**, while another advisable measure would consist in replacing incandescent lamps with fluorescent ones.

The **maintenance** of central heating boiler systems is another measure of significance. It is, however, estimated that maximum benefits from the promotion of these interventions will only be drawn after the year 2000, due to the multiple policies necessary and the large number of consumers directly concerned.

Architectural competitions for the award of the most innovative new buildings, designed according to solar architectural principles or to their energy efficiency, are scheduled.

During the years 1997-1998 many activities concerning information campaigns, seminars, national and European conferences, exhibitions of pilot projects of solar architecture and planning have been held in different cities in Greece, as well as many training and educational course at all levels. Also, training and information campaigns have been carried out, as well as a plethora of pilot applications, which also include low energy installations into public buildings, such as hospitals, schools, sports centers, etc. Also, seven Environmental Education Centers have been established where students participate in special Environmental Education programs. A number of 1,400 projects on Environmental Education have been implemented voluntarily in schools of secondary education, and another 1,300 in those of primary education.

6.5.2.2 Results & Impacts

Based upon the evidence of socio-economic analyses and especially behavioral patterns, it is the housing sector, which has responded and will continue to respond with increased interest to taking up different energy saving solutions. A large proportion of this interest involves the use of solar energy.

Apart from the direct effects such as energy saving and stabilization of CO_2 emissions, expected benefits from the completion of the Action Plan "ENERGY 2001" are the considerable reductions in the costs of heating and air-conditioning.

The indirect effects of this are several and concern different factors; early evidence shows that the private sector has already been motivated by the substantial economic benefits in the production of suitable designs, building materials, application of appropriate technologies and finally (and equally important) the production of energy from renewable sources.

The beginning of the comprehensive approach to energy saving in buildings has also had considerable effects in the saving of water consumption. The technical specifications of housing and development plan expansion studies ordered by Ministries, Local Authorities and Housing Associations also bear the signs of this influence.

6.5.2.3 Barriers and Conflicts

The comparatively recent application of innovative designs and technology, especially in relation to energy saving, has been ad hoc and lacking in a comprehensive approach. Thus at national policy level, at least, very few of the basic principles of sustainability which concern the built environment have been formally adopted.

Such matters as rational use of natural resources in general and energy management in particular, especially the promotion of solar bioclimatic architecture and planning, have received minimum attention and were the main concern of research institutions, which had limited monetary resources for public enlightenment and dissemination.

It is therefore estimated that the important factor of social acceptability and the fairly major changes in mentality on the part of the users will take a long time to achieve.

The existing energy consumption patterns and consumer characteristics constitute an important barrier and target group which will require the long-term application of specific policies and strategies in order for the Action Plan to be effective.

The necessity for energy coordination and cooperation is considered to be another problematic area, given the fact that in the past it has proved to be one of the more difficult problems in the implementation of comprehensive plans.

The alignment of Greek standards and regulations with those of the European Union requires significant levels of investment, which the troubled economy of the country often finds difficult to achieve. These concern building construction materials but also technical infrastructure, specialized skills and training as well as expensive and sophisticated certification mechanisms.
Finally, the powerful interests of agents promoting conventional technology, who offer continuously reduced prices for their products and design as opposed to the fairly high initial cost of acquiring and installing technologies which promote sustainability in the energy sector, can be considered as a factor which creates both conflict and a barrier to the build-up of momentum for the application of the Action Plan.

6.5.2.4 Transferability

The variety of Greece's geomorphology and climate, despite its small physical size, constitutes a tremendous opportunity in the transferability of the expected results. The effort which has been made in the formulation of an Action Plan should take into account the substantial climatic and topographic differences, which range from alpine (northern Greece) to semi-arid zones (island regions). Furthermore, designing for large conurbation's such as the Greater Athens Area (where nearly half of the country's population lives) and mainland and island settlements with tiny populations that increase many times over during the summer months offers the opportunity to diffuse valuable experience from the application of successful examples involving small-scale developments where extreme conditions occur and where a large proportion of the built environment is produced by private means.

7.0 ANSWERS TO QUESTIONS AND CONSEQUENCES

What will cities look like and what are the consequences for city planners?		
Resources	**Main issues**	**Consequences**
Land	Efficient use of land Conservation of open space and green areas	Restricted suburbanisation More low density building
Energy	Reduce energy consumption Optimising transport infrastructure	Use local sources, district heating, CHP, renewable sources Upgrading energy efficiency of existing building stock Create new transport networks
Water	Drinking water conservation Urban water management, groundwater protection	
Materials	Urban waste management Building materials	 Use of local materials (no transportation)
Other aspects	Sustainable planning	Maintain rural settlement structure
What kind of buildings will we build and how will we adapt existing buildings? What does this entail for initiating and designing?		
Resources	**Main issues**	**Consequences**
Land	Efficient use of land Greater use of existing buildings	Multi-functional buildings More refurbishment and retrofit activities LCA+LCC
Energy	Energy-efficient buildings Optimising heating/cooling/lighting Upgrading energy performance of existing building stock	Renewable energy sources Day lighting/passive lighting Passive heating/cooling Hybrid systems for heating
Water	Drinking water conservation	Rain-water use
Materials	Upgrading existing building stock Raw material efficient building	Use of local materials and traditional building methods Low embodied energy-local materials
Other aspects		
What kind of buildings will we build and how will we adapt existing buildings? What does this entail for constructing and demolishing?		
Resources	**Main issues**	**Consequences**
Land	Protect nature	
Energy	Energy efficient construction sites	Minimise transportation need Energy saving refurbishment
Water		
Materials	Efficient use of materials/recycling	Low embodied energy
Other aspects	Optimise building process	Total quality management Quality standards for whole buildings

What kind of buildings will we build and how will we adapt existing buildings? What does this entail for operating and maintenance?		
Resources	**Main issues**	**Consequences**
Land	Minimise non-public transportation needs	Education of building managers and employees
Energy	Optimise energy consumption	Tools and systems for energy management
Water	Optimise water consumption	Use of rain water and re-use of grey water Tools and systems for water management
Materials	Extend service life of buildings	Adapt buildings for future needs of occupants Planned maintenance and refurbishment programmes
Other aspects	Integrated management	Performance characteristics
What kind of buildings will we build and how will we adapt existing buildings? What does this entail for components, materials, services and assembly?		
Resources	**Main issues**	**Consequences**
Land		
Energy	Energy saving	Optimum use of new technologies: Heat recovery and storage, CHP-units, Electrical heat pumps, PV-cells, passive and hybrid technologies for heating and cooling, passive lighting systems,
Water	Water saving systems	Rain water storage systems.
Materials		Low embodied energy
Other aspects		Environmental products and methods

What kind of buildings will we build and how will we adapt existing buildings? What does this entail human resources and skills needed in the construction industry?	
Main issues	**Consequences**
Qualified labour	Multi-skilled crews; non-specialisation; professional barriers become less important Multi-skilled labour able to handle both old and new materials
Building process management becomes more complicated	Integrated knowledge of whole building process
Decision making processes becoming more complicated	Life cycle assessment
More need for interdisciplinary education	New curricula for designers and construction engineers to overcome professional barriers. More specialisation in environmental issues.
Public awareness should increase	Demonstration projects information campaigns.
Standards and regulations	Adoption of environmental criteria

7.0 STRATEGIC RECOMMENDATIONS

The following are considered as general strategic aspects that should be covered. Most issues had been covered with the answering to the main questions above.

General policies

- Sustainable urban development.
- Completion of the highways national system.
- Reduce the need for travel while protecting social and economic needs for access by changing urban form and promoting new communication technologies.
- Development of educational programmes in the higher levels.
- Training courses and practice dissemination.

Construction policies

- Need for land use regulations with respect for green areas and open space.
- Planing for renovation of the existing building stock.
- Introduction of rules and regulations regarding sustainability in construction.
- Introduction of standards dealing with longevity and multiple use of buildings.
- Saving of resources in construction activities.
- Support for environmentally friendly materials.
- Eco labelling standards in building products.
- Life-cycle considerations in product development.
- Planed maintenance
- Quality standards for whole building - quality management.
- The integration of environmental studies in building construction.
- Safety requirements.
- Marketing standards.

In order to cover the need of environmental protection several criteria will have to been introduced (not yet required by building codes but important to apply new ideas to building construction) such as the

- Renewable or non-renewable raw materials.
- Human health and safety impact due to life stages of the building as well as the fire impact.
- Life cycle assessment approaches, which are an integrated part of continuous product development, process.
- Energy balances due to operation stages of raw material acquisition - building materials production - transportation - and construction.
- Operation energy balances due stages of operation, maintenance, demolition and waste treatment

On this purpose **a sustainable building analysis** in order to be compatible with the above aims and strategy should be structured as the following methodology:

- Formulation of the main characteristics of a typical building on its building elements and the used materials.
- Specification of the building elements upon building materials layer and assessment of their technical characteristics (thickness, volume unit weight, area unit weight, conductivity coefficient).

- Determination of the environmental impact attributes, which are the initial embodied energy and the equivalent emissions of CO_2 and SO_2.
- Calculation and distribution of the data to a representative functional unit which is 1 m^2 of every building element.
- Calculation of the environmental attributes for the entire building and distributions of the data to a representative functional unit which is 1 m^2 of surface of the building.
- General conclusions specified in comparison with the operation energy consumptions of the building.

8.0 DEMOSTRATION PROJECTS-CASE STUDIES

Some technical offices in Greece are working in the field of bioclimatic architecture and their projects are mostly in the private. In some cases there are hospitals and office buildings.

8.1 Examples of Energy efficiency houses

In Greece, sustainable housing is still in infancy. Considerable preparatory work in the form of regulations and information is already taking place, but has not yet had any measurable impact on housing construction. The highest percentage of measures has been adopted in relation to energy.

The following descriptions are some representative residential "energy efficiency" houses in Greece.

- The solar village of Pefki-Lykovryssi

Location - Athens 1989
It's a village of 435 houses

Passive system for heating	Passive system for ventilation
Direct solar gain	Cross ventilation
Sun space	Sun protection
Trombe wall	

Also solar collectors are used for water heating

- Two storey building

Location: Drosia - Thessaloniki 1988
Total building area 231m^2 - total building volume 806m^3

Passive system for heating	Passive system for ventilation
Direct solar gain	Cross ventilation
Sun space	Sun protection
Trombe wall	

Total thermal load per year. 25494Kwh
Passive system participation 48%

- Two storey building

Location: Panorama - Thessaloniki 1990
Total building area 222m^2 - total building volume 679m^3

Passive system for heating	Passive system for ventilation
Direct solar gain	Cross ventilation
Sun space	Chimney effect
Water walls	

Passive system participation 45%

Also some buildings include active solar heating system, such as solar collectors for water heating and heat pumps.
In Greece there is no official registry of the existing "low energy efficiency" building stock.

8.2 Queen's Tower Park Athens - Environmental Awareness and Training Center Park

"Queen's Tower Park" is a 1.5-km^2 tract of public land situated in the northern part of West Athens. This Athens Urban Pilot Project is an innovative idea in tackling urban problems and experimenting with new ideas in the implementation of sustainable urban policy. Its experimental nature is of particular importance, since it is developed in a peripheral area of the city inhabited mostly by low-income population. Incorporated in the Park design is an amalgam of physical and social factors with an emphasis on natural ecosystems in order to provide leisure opportunities and training activities in the framework of environmental awareness. The improvement of transportation modes to the West Athens area and the development of commercial and service functions also form part of the project.
The policy goals are focussed on the following general statements.

- Improvement of the overall environmental quality in West Athens
- Enhancement of leisure and sports opportunities
- Increase of environmental consciousness
- Extension of the benefits of economic growth to local communities
- Assistance to local authorities to form integrated approaches to problems
- Preservation/rehabilitation of historic buildings.

8.4 Low energy efficiency settlement in Thessaloniki

In the western part of Thessaloniki a settlement project is under development consisting 24 houses. The need of electric power will be covered from photovoltaic panels and space heating will be attained by solar passive system participation. Extra energy requirements will be covered with the use of natural gas. Finally the need of hot water will be covered with the use of a solar collector at the roof of each house. Alteren Inc- Thessaloniki 1998 designs the project.

9.0 CONFERENCES AND OTHER TRADE PROMOTIONS

HELECO (every two years since 1993. Next June 1999)

Heleco is an International Exhibition on the Environmental Technology and is a two-fold function.

- A commercial exhibition on the latest technological achievements, regarding environmental management and protection.
- A scientific conference discussing all the latest technological development which concern various environmental problems (water, atmosphere, solid waste, environmental management, urban design and development)

AERION - December Athens. (Annual): An exhibition specializing in energy and natural gas machinery, equipment, parts and technology. The 1993 and 1995 exhibitions were sponsored and the seminars were funded by the EU Energy Committee.

INDEX '96 - (Annual): A general fair with special sections for industrial, electrical and mechanical products and parts. It takes place in Athens annually during the second week of November.

INFACOMA '97: An annual exhibition (Thessaloniki) organized for the tenth time. This is a building material fair with special sections for any equipment and parts.

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KTISMA: An annual exhibition, organized since 1991. This is a building material fair. It takes place in Athens annually the second week of November.

ERGODOMI: An annual exhibition, organized since 1996. This is an Infrastructure and Major Public and private project machinery, equipment, products and materials fair.

CLIMATHERM '97: An annual exhibition, organized since 1996. This is an air-conditioning, heating, refrigeration, and renewable energy equipment and products fair. It takes place in Athens annually the last week of February.

10.0 REFERENCE

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