SOLAR HEATING AND PASSIVE COOLING

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1. Introduction

Passive solar heating, cooling and lighting techniques have reached a high degree of technical maturity. Large scale applications, especially in new settlements, have shown that very high energy gains can be achieved while the thermal and visual comfort as well as indoor air quality are very satisfactory, (IEA, 1997). Further penetration and use of solar technologies is associated with their adaptation to the new conditions almost imposed by the specific social, economic and technical trends dominating the overall sector of the built environment.

Penetration of passive solar design in Europe is not negligible. There are some 10000 to 20000 passive solar dwellings in the European Community but there are probably no more than a few hundred other buildings which incorporate such features, (EEC, 1994). However, according to (EEC, 1990), passive solar supplies EEC countries with the equivalent of 96 MToe of primary energy per year, which represents the 13 percent of the total annual buildings consumption. According to Morse, in USA during the 80's there were almost 150000 passive solar homes and 10000 non residential buildings while it is estimated that some thousands of buildings being added each year. It was also estimated that passive solar constituted as much as 5 to 15 % of brick or masonry material sales, (USDOE, 1984).

The implementation of new approaches to solar thermal energy in architectural design was the theme of several research programmes that have been undertaken and executed during the last years. Research and Development actions have contributed to further "improve our understanding of the science and engineering of these technologies, to create linkages between researchers and practitioners, to reach the mainstream of building design professions and to awaken their interest in energy - efficient building and improved building performance". In parallel some forms of information and support appropriate to the needs of different users have been established. Recent knowledge gained through intensive research and appropriate applications on the field of energy

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efficiency and solar utilisation, offer the necessary products, tools and techniques that permit the design of outstanding structures revealing ambitious architectural concepts, characterised by the minimum energy necessary for the heating, cooling and lighting as well as for the best indoor environmental quality. It is well known that despite the growing stock of buildings in industrialised countries, the amount of energy in these countries is almost constant since the early seventies, (Pollock Shea, 1988). Due to increased energy efficiency, buildings in these countries use 25 per cent less energy per person than they did in 1973, which is the equivalent of 3.8 million barrels of oil every day - more than the output of the North Sea.

As stated by (C. F. Reinhart et all, 2001), ‘solar buildings deals with common architectural practices as well as on the very recent developments which supply building designers with an ever-increasing catalogue of components and concepts such as advanced windows and better insulation materials, solar cells and collectors, heat pumps, daylighting, integrated lighting and shading control systems, free nocturnal air cooling, pre-heaters like air heat recovery and air-to-ground heat exchangers for preheating in winter etc.’ , Figure1. Passive solar heating, cooling and lighting techniques have reached a high degree of technical maturity. Large-scale applications, especially in new settlements, have shown that very high-energy gains can be achieved while the thermal and visual comforts as well as indoor air quality are very satisfactory

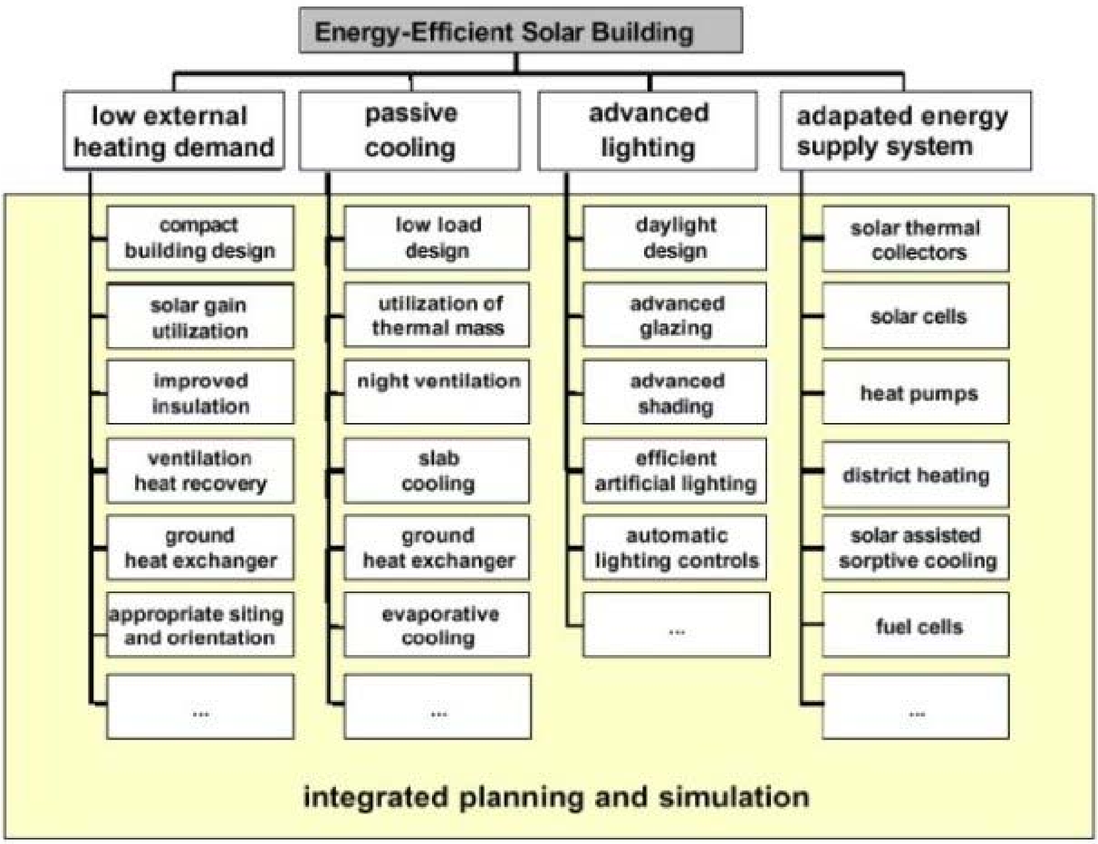

Figure 1: Main Components of solar buildings (C.F. Reinhart et al. 2001)

Thus, recent studies, (Wienold 2000), have shown that solar energy to the total energy demand for space heating (solar gains, internal gains and active heating) is already substantial in buildings across Europe. The Table 1 shows the individual level for several EU member states.

Country Solar Fraction

Country	Solar Fraction
Norway	10 %
Germany	16 %
Belgium	11 %
Finland	15 %
Greece	16 %

Table 1: Solar fraction is defined as the contribution of usable solar gains for heating to the total heating demand including active heating, solar and internal gains in the heating season.

These high solar contributions partly stem from the exponential development of the European solar collector and energy-efficient window market , see Figure 2.

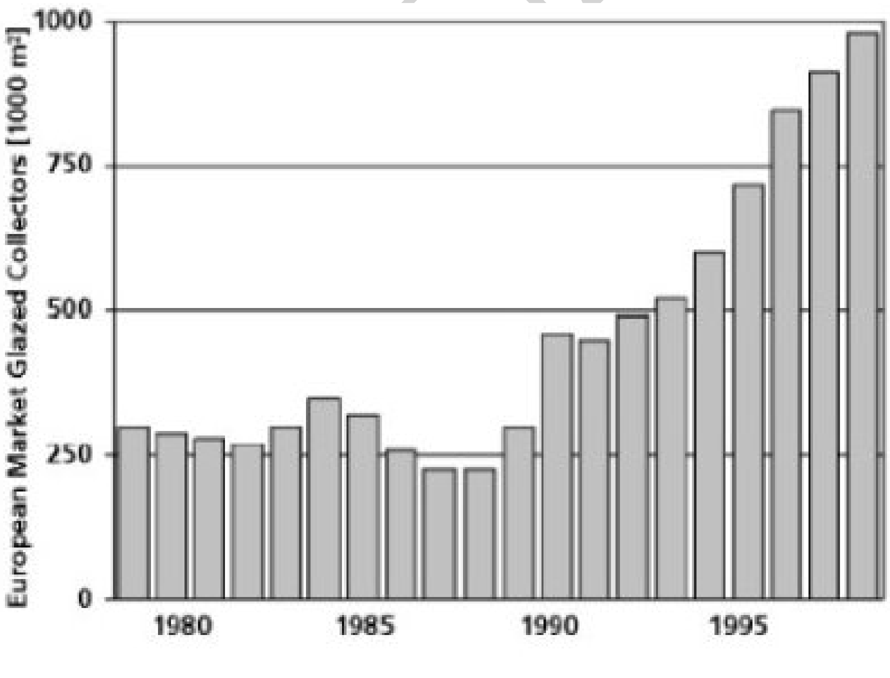

Figure 2: Increase of the installed solar collectors in Europe (From C.F. Reinhart et all. 2001)

Existing buildings and their retrofitting provides by far the largest potential for the incorporation of passive solar technologies and energy efficiency measures into buildings. Within many countries there is a considerably higher activity in retrofitting and reusing buildings, than in constructing new ones. It is characteristic that actually more than 70 % of the building's related investments in Western Europe are channeled to urban renewal and building rehabilitation. In the tertiary sector, retrofitting of the post war stock is seen in the property market as the major area of activity for the next few years, and thus the incorporation of solar energy could be significant.

The main retrofitting features related to the use of solar energy in buildings are: a) Actions aiming to result in probable reduction and even sometimes, complete removal of the air conditioning, or the avoidance of it being added, b) Actions aiming to introduce or improve daylighting, and c) Actions aiming to introduce passive solar heating techniques and components. In particular, retrofitting measures should focus on a series of specific actions dealing with the improvement and optimization of the building systems and components as:

(1) Redesign of openings, improvement of external opaque elements, microclimate improvements,
(2) Optimisation of control system to couple efficiently conventional with solar systems,
(3) Improvement of HVAC system to use ambient and solar energy, improvement of the lighting system to incorporate daylight,
(4) Use of alternative passive cooling equipment, and
(5) Improvements in hot water systems and mainly integration of active solar systems.

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Biographical Sketch

Matthew Santamouris is Associate Professor on Energy Physics at University of Athens and Visiting Professor to the School of Architecture, Low Energy Unit at University of North London, U.K He participated as an expert to many international Bodies and Associations (including PLEA, Ispra JRC, EUREC Agency, ENBRI, AIVC, European Intelligent Group) and an external reviewer and evaluator of Research Programs on Energy and Environment for the Greek Government and the European Commission. He has co-ordinated several International Research and Development Programs. He has edited or authored various books on the topics of Passive Cooling of Buildings, Natural Ventilation of Buildings, Energy in the Urban Environment, Building Urban Climatology, Energy Rehabilitation of Buildings, Environmental Physics, Solar Collectors and Greenhouses, Renewable Energy Sources, Thermal and Visual Comfort of Buildings. He is editor and reviewer of a number of national and international scientific journals.

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