PASSIVE SOLAR ENERGY AS A FUEL 1990–2010

J. V. DOGGART
The ECD Partnership
11-15 Emerald Street
London WC1N 3QL
United Kingdom

ABSTRACT. The purpose of this study was to assess the current and potential future use of passive solar energy in buildings in Europe up to the year 2010. The study was commissioned by DG XII of the Commission of the European Community and a summary report is available. Data on the use of passive solar energy for heating, and passive design for the avoidance of overheating and the provision of daylighting, were collected from published sources and experts in all European countries. The study demonstrates that there is considerable potential for using passive solar design for heating, cooling and lighting in all countries of Europe and that the current equivalent saving of 230 million tonnes of CO_2 could be increased by 103 million tonnes by 2010 if positive action were taken to promote passive design in buildings.

1. Purpose of the Study

The study set out to answer three main questions:-

- How much solar energy is used currently in buildings in the European Community?
- How much solar energy could be used in the future - in the years 2000 and 2010?
- What could be the consequent reduction in pollution, particularly carbon dioxide (CO_2)?

A summary report is available and background material and research details are given in a full report prepared for the Commission of the European Communities (CEC).

2. Using Passive Solar Design

2.1 PASSIVE DESIGN

directly through the windows or indirectly through sunspaces, wall panels, etc., and its use or storage inside the building with little or no use of fans or pumps.

Cooling by passive solar design involves shading, natural ventilation and the use of naturally cooled air (from the ground or evaporative cooling) to prevent the building overheating.

Daylighting by passive design means allowing natural light to enter deep into a building and ensuring that artificial lighting is only used when the natural lighting is insufficient.

Good design optimizes the utilization of solar energy and can achieve large savings in the amount of conventional fuel required for heating, cooling and lighting.

2.2 SOLAR DESIGN IN NEW AND EXISTING BUILDINGS, IN NORTH AND SOUTH

All buildings make use of some solar gain for heating and lighting and this use can be increased at any stage in a building's life. The simplest and most effective way is at the design stage for a new building, but some solar features can also be introduced with significant effects during major refurbishments. In addition, it is possible to add certain solar measures onto an existing building at any time.

Passive solar design can be applied in all climates, though naturally in different ways. In the northern latitudes where winters are long and cold most of the available solar gains can be used to reduce consumption of fossil (and nuclear) fuel for heating. In Mediterranean areas, passive design is used to best effect to reduce or prevent overheating and consequent use of air-conditioning; in addition, the small heating loads which exist in these regions can be minimized. Daylighting design is applicable in all climates.

3. Methodology for Estimating Solar Energy Use

3.1 THE "SPREADSHEET" AND INFORMATION SOURCES

The method used was to build up the total usage of solar energy in the European Community for all the relevant sectors in all the various countries. Computer "spreadsheets" were developed - one for each country - and available information, estimates and projections inserted. Much of the information required was simply not available, so estimates were made on the basis of what did exist, comparison with other countries and expert opinion.

3.2 BASE AND "TECHNICAL POTENTIAL" SOLAR CONTRIBUTIONS

The "base case" solar energy usage was defined as the contribution of passive solar design to heating and cooling loads if no action is taken to increase the usage in the future.

The "technical potential" solar contributions to heating, cooling and lighting were defined as the maximum achievable overall in the years 2000 and 2010. They take into account technical limitations (such as the overshading provided by neighbouring buildings, etc.) but otherwise assume that all buildings would be constructed or refurbished according to solar principles.

3.3 DWELLINGS

Using solar energy to heat houses and other dwellings is the best researched and documented area of passive solar design. The current solar usage was built up for each country from the number of dwellings, their gross heating demand and the percentage solar contributions as determined from monitoring projects. New build, refurbishment and demolition rates were then used together with the solar contributions monitored in new and refurbished solar dwellings to

estimate the technical potential.

The need for cooling in dwellings was only considered for countries in southern latitudes. Passive or natural cooling design was estimated in this study to currently provide half the demand in dwellings which have no air-conditioning but where cooling is needed.

In dwellings, daylighting was not considered as an area where solar energy was likely to make a contribution to fuel savings.

3.4 OFFICES, FACTORIES, SCHOOLS, ETC.

The non-domestic sector has far more diverse building types and less information is available on them. Broad estimates were made mainly on the basis of current energy usage and predictions of increases in energy consumption available from CEC research. The contributions which solar design might make to heating, cooling and lighting for the years 2000 and 2010 were built up.

3.5 REDUCTION IN POLLUTION FROM SOLAR DESIGN

The reduction in CO_2, SO_2 and NO_x pollution and nuclear waste for each country was calculated from the breakdown of the different types of fuel in the country and the total equivalent savings resulting from the solar design.

4. Results of Study – Solar Energy Use and Pollution Reduction

4.1 USE OF SOLAR ENERGY COMPARED WITH OTHER FUELS IN 1990

Passive solar design at present supplies the European Community with the equivalent of 96 million tonnes of oil equivalent (mtoe) of primary energy per annum. This is 9% of the total fuel used in the European Community (Figure 1). It is larger than the amount of coal directly burnt for heating, which amounts to 6% of the total. In the building sector alone (i.e., excluding industrial process heat and transportation energy use) solar design supplies 13% of the total (Figure 2). Thus it is clear that solar energy is already a very important fuel in Europe.

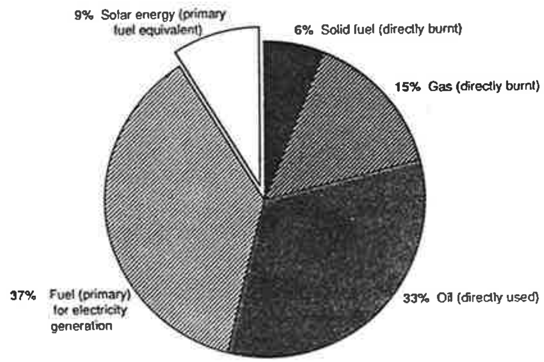

Figure 1. Total use of fuel in the European Community in 1990 (including transport and industrial process use)

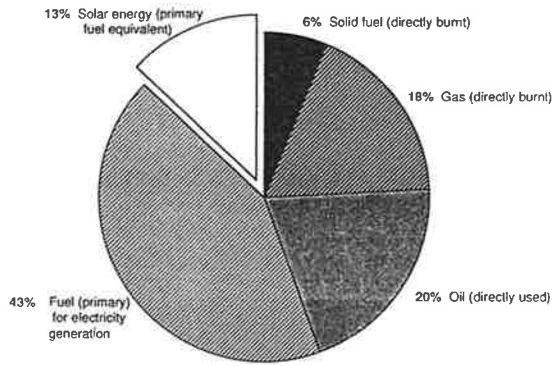

Figure 2. Use of fuel in dwellings and non-domestic buildings in the European Community in 1990 (excluding transport and industrial process use)

4.2 SOLAR ENERGY USE IN THE FUTURE

If no specific action is taken to promote the use of passive solar design in the future, a small rise of 8% above the 1990 levels is predicted by the year 2000. It is expected that this will fall back to 6% above the 1990 figure by the year 2010. The reduction is due to the lower heating demand resulting from higher insulation standards.

If, however, specific action is taken, there is the potential for a great increase in the use of solar energy. By the year 2000, the overall amount could be increased by 27% of the 1990 usage - an increase of 26 mtoe. By 2010, the increase could be 54% or 52 mtoe per annum.

These potentials are the maximum technically possible and include allowances for buildings which cannot be oriented optimally, etc. In practice, the potential will be reduced by such factors as low take-up rates and poor design and operation.

4.3 WHERE MOST SOLAR ENERGY IS USED

Figure 3 shows the increase in the contribution from solar energy in each of the five categories (domestic heating, non-domestic heating, domestic cooling, non-domestic cooling and non-domestic lighting) for the European Community as a whole from 1990 to the years 2000 and 2010.

Of the five categories, heating currently receives the greatest contribution from solar energy in absolute terms (it was nearly 76 mtoe per annum in 1990). However, the largest increase is forecast for the use of daylighting in non-domestic buildings; the increase amounts to nearly 18 mtoe per annum by 2010. The predicted growth for solar heating in non-domestic buildings is also large with an increase of over 17 mtoe per annum in 2010 compared with 1990. This reflects the relatively high rates of new construction and refurbishment in this sector compared to housing.

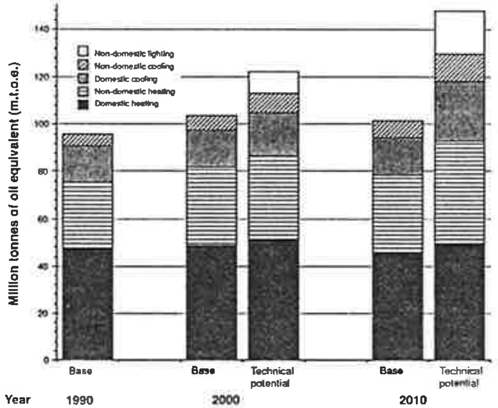

Figure 3. Contribution of solar energy to heating, cooling and lighting buildings in the European Community in 1990, 2000 and 2010

Note: Base Case = no action taken to increase solar usage.
Technical potential = all potential solar usage exploited.

The overall contribution of passive solar design to reduction of cooling loads is smaller than its contribution to the heating requirements of buildings. This is due to the small need for cooling within Europe as a whole. Within individual countries, however, the picture is very different. For instance, the northern countries of Denmark, Ireland and the Netherlands have negligible cooling demand whereas Greece, Spain, Italy and Portugal achieve 50% of their total technical potential solar contribution through passive cooling design. Taking the Community as a whole, an increase of 9 mtoe per annum in the contribution from natural cooling in dwellings is possible by 2010 (compared with 1990) - a significant growth rate.

Whilst the largest use of solar energy, in absolute terms, undoubtedly comes from the countries with the largest populations, the greatest growth rates for passive solar design are likely to come from countries in southern latitudes where there is a potential for increasing the contributions made by solar design to heating, lighting and cooling.

4.4 REDUCING ATMOSPHERIC POLLUTION BY USE OF SOLAR DESIGN

The reduction in use of fossil fuels brought about by the current usage of passive solar energy prevents 229 million tonnes of CO_2 being emitted to the atmosphere per annum. This represents nearly 17% of the CO_2 which would be produced if the buildings in the Community experienced no solar contribution. Emission of 1.3 million tonnes of SO_2 and 0.56 million tonnes of NO_x (oxides of nitrogen) is also avoided by use of solar design. The potential cuts in pollution which could arise from use of passive solar design throughout Europe in the future are shown in Figure 4.

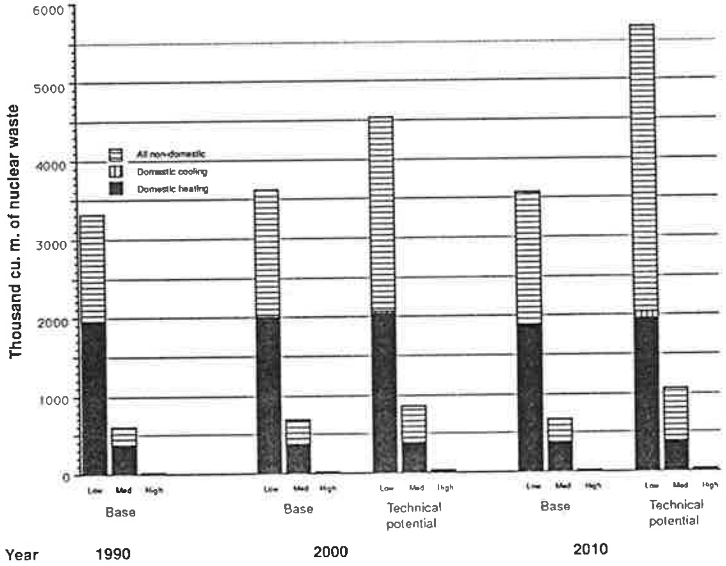

Figure 4. Savings in atmospheric pollution arising in the European Community through use of passive solar design

Notes: 1. Base case = no action taken to increase solar usage.
Technical potential = all potential solar usage exploited.
2. SO_2 and NO_x reductions are largely due to implementation of legislation to reduce power station emissions of these gases.

If the technical potential solar contributions were achieved, the amount of CO_2 saved per annum by the year 2000 would rise to 272 million tonnes, an increase of 19% compared with 1990. By 2010, the savings would be 332 million tonnes a year, an increase of 45% over 1990.

In the future, legislation will be implemented to reduce emission of SO2 and NO_x (principally "acid rain") from power stations. If the targets established by this legislation are met, there will be less scope for reduction of emissions of these gases from use of passive solar design.

Three countries - Germany, Italy and the UK - currently contribute two thirds of the total reduction in CO_2 emissions due to solar design. Because of its large nuclear programme, France contributes only 9% to the savings made in the Community as a whole. The picture will remain broadly unchanged up to 2010, assuming the technical potential is achieved.

The increased savings in CO_2 emissions possible by 2010 vary greatly between countries, from 19% in Belgium to 104% in Greece. The differences roughly reflect the changes in solar contributions, the countries in southern latitudes generally showing the highest percentage savings.

4.5 REDUCING NUCLEAR WASTE BY USE OF SOLAR DESIGN

At present, the production of nuclear waste is 18% below what it would be if passive solar design made no contribution to heating, cooling and lighting the buildings in the European Community. Although seven countries use nuclear power, France is the major producer by far and contributes around 70% of the 1990 savings and 57% of the 2010 potential savings. Overall, solar design could, by 2010, increase savings of nuclear waste by around 70% of the 1990 level.