Contents page

Reducing climate change with EPS insulation

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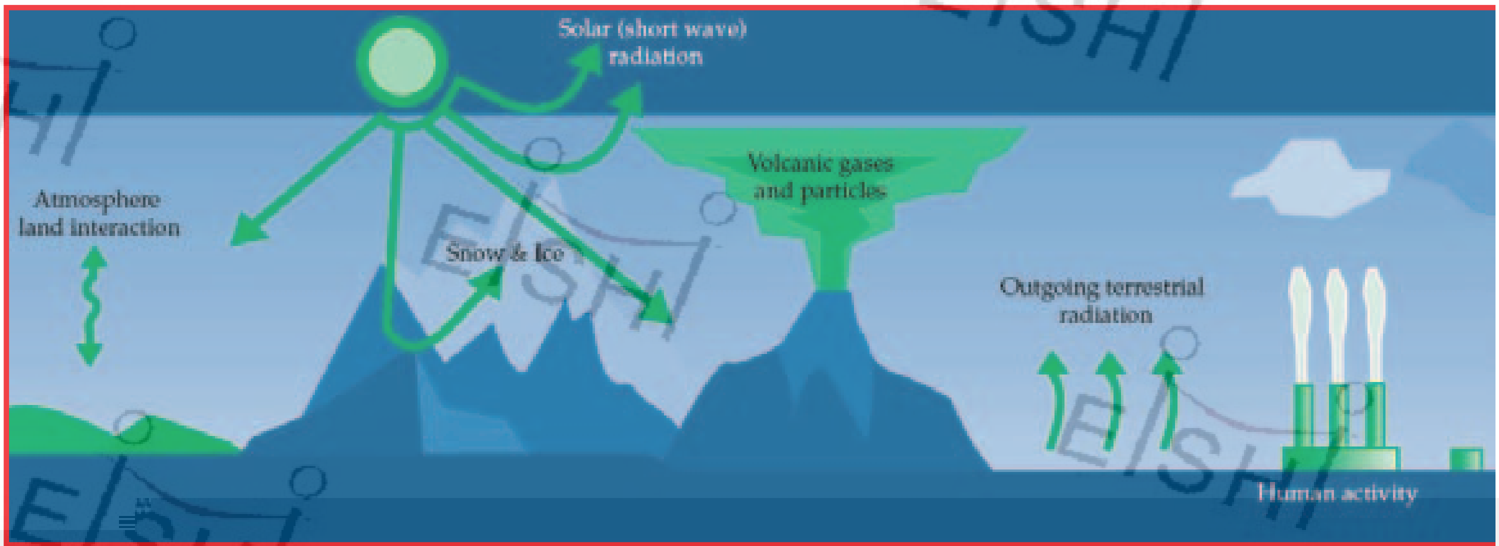
GI This document, first published by EUMEPS, the European Manufacturers of Expanded Polystyrene, discusses climate change due to global warming, and the factors that influence this phenomenon. It then goes on to describe how the use of expanded polystyrene insulation materials can assist in the minimisation of global warming.

The climate of a region is an average of its daily weather patterns taken over time-periods ranging from months to years to centuries. Climate change is one of the most serious environmental threats facing the world today. Over the last few years extreme weather events have shown us how vulnerable we are to changes in the earth's climate, and how devastating the impacts can be. Even as we left the 20th Century, severe storms left a trail of death and destruction across Europe. It cannot be said for certain that individual events like these are the direct result of man-made changes to the climate. However we can expect extreme weather events to become more intense as temperatures rise and there is now no doubt that the world is getting warmer. The global mean temperatures that are quoted by climate change scientists are estimates only. One figure is given as the result of averaging, over a period of time, the night and day temperatures over land and sea masses in both Northern and Southern hemispheres. Over the past 100 years, the global mean temperature has risen by between 0.3°C and 0.6°C. The significance of this rise can be measured against the extremes of the past. During the coldest period of the most recent ice age, the global mean temperature is estimated at 3°C lower than today. During the warmest interglacial period, it was just over 2°C higher: an overall fluctuation of about 5°C. Europe's own climate has varied from 2°C warmer than today in the 1200s to 1°C cooler in the 1600s. In England, the 1990s experienced four out of the five warmest years in a 340 year record, with 1999 being the joint warmest year ever recorded.

Scientists link this rate of increase to the build-up of concentrations of certain gases in the atmosphere, particularly carbon dioxide. This disturbs the natural energy balance of the Earth-atmosphere system and exerts a 'radiative forcing', leading to continued global warming. Predictions of the rise in global mean temperatures over the next 100 years range from 1.5°C to 5°C. This is compared with the total variation of 5°C in the last 160,000 years. The impacts of unchecked climate change will be felt around the world. Rising sea levels threaten the existence of some small island states and put millions of people at risk in coastal areas. Temperature increases and drought will affect people's health and way of life, and may mean the irreversible loss of species of plants and animals.

Internationally, countries are



Global INSULATION

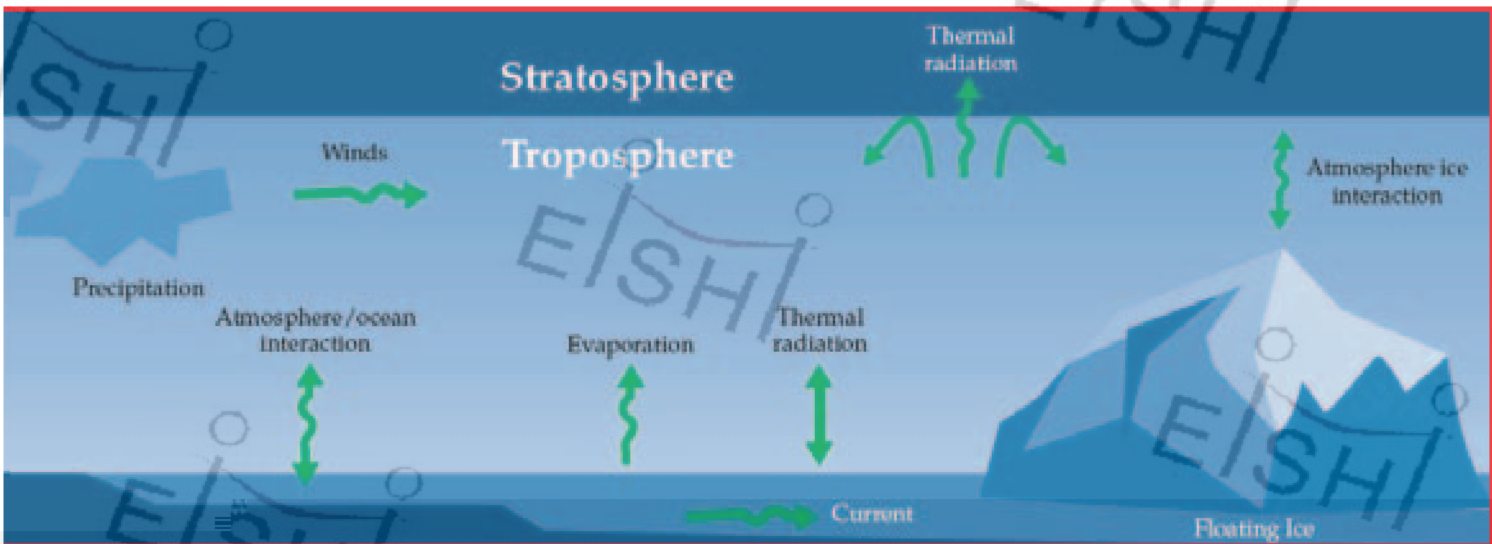
taking action through the United Nations Framework Convention on Climate Change and the Kyoto Protocol. Under the Kyoto Protocol, negotiated in December 1997, the developed countries agreed to cut their combined emissions of greenhouse gases by 5.2% below 1990 levels over the period 2008 - 2012. The greenhouse gases covered by the Kyoto Protocol are carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride. For the first time, these targets are legally binding and different countries have taken on different targets, reflecting their national circumstances. European and other countries are working together to ratify the protocol and make the emissions reductions a reality.

The greenhouse effect

The greenhouse effect results from increased emissions of certain gases associated with modern day life. Most of the heat from the sun (short wave solar radiation) that reaches the earth is absorbed by the surface and warms it up, while about a third is reflected back through the atmosphere into space. Some of this reflected radiation is trapped at the top of the atmosphere (troposphere) by a layer of gases which absorb and recycle the heat back towards the earth's surface and so warm it still further. This entirely natural process is called the 'greenhouse effect' and keeps the earth 33°C warmer than it would be without the recycled heat. Unlike a glass greenhouse, where trapped hot air cannot escape, the planetary 'greenhouse' does allow some heat to escape and acts like a natural thermostat to prevent the earth from over-heating or freezing over. Without it, the atmosphere would have burned off long ago, leaving the surface temperature at about -18°C instead of the present day 15°C (Ref.1). Water vapour and clouds absorb a great deal of incoming solar radiation. Water vapour accounts for around two-thirds of the natural greenhouse effect. Clouds, which operate from ground level up to a height of 12km, also reflect some radiation back to space before it reaches the earth's surface. The other part of the greenhouse effect is due to a number of gases collected together at the tropopause, some 15km above the earth's surface. Most of these gases occur naturally and may be added to by human activities. A few of these gases are man-made. Carbon dioxide, produced as a result of burning fossil fuels for energy is the major contributor. Experts agree that there is more greenhouse gas in the atmosphere as a result of this increased fossil fuel burning. In addition emissions from animals, especially as a result of intensive farming, are increasing. Carbon dioxide (CO_2) forms just 0.03% of earth's lower atmosphere, but at 356ppmv (parts per million by volume) represents the greatest part by volume of greenhouse gases. Concentration of methane (CH_4), ozone (O_3), nitrous oxide (N_2O) and the man-made halocarbons are measured in parts per billion by volume. The term used to describe the influence or disturbance that these gases and other processes have on earth-atmosphere radiation balance is radiative forcing. Greenhouse gases like water vapour and CO_2 are said to have a positive radiative forcing potential because they have a warming effect. Sulphate aerosols (airborne particles) and dust from volcanic activity can have a negative radiative forcing potential or cooling effect. The radiative forcing due to the increase in CO_2 from 280 to 356ppmv has been estimated as 1.56 watts per square metre.

Global warming potential (GWP)

The influence a greenhouse gas has on the radiative balance is based on its ability to absorb solar radiation and on its lifetime in earth's atmosphere. The index developed by scientists for policy-makers to use in making comparisons between the effects of different greenhouse gases is termed the global warming potential (GWP). The GWP measures the total energy absorbed by 1kg of released gas over a fixed period of time. CO_2 is given a GWP of 1.0. The international Panel on Climate Change gives a typical uncertainty of ±35% relative to the GWP of CO_2. It is a difficult concept to apply to short-lived gases and to gases reacting with each other. The European Community and its member states agreed at Kyoto to an 8% cut in the combined emission of greenhouse gases. Carbon diox-



ide represents the greatest part by volume of greenhouse gases. The estimated total CO_2 emissions in Europe were 3200Mt in 1990 (Ref.2) and are anticipated to grow, if unrestricted, to 3459Mt per year by 2010. The European targeted reduction by 2010 is 15% (739Mt).

CFCs = Chlorofluorocarbons (contain chlorine and have high ozone depletion potentials (ODPs))
HCFCs = Hydrochlorofluorocarbons (contain chlorine but have low ODPs. They have shorter atmospheric lifetimes than the CFCs (because they contain hydrogen), and are thought to be much less damaging to stratospheric ozone.)
HFCs = Hydrofluorocarbons (contain no chlorine and have zero ODPs, but are greenhouse gases.)

The main alternatives to CFCs.

The ozone layer

Ozone depletion is also a major subject in the environmental debate. The extent of the problem and its effects are not certain, but action is being taken. Ozone, a variation of oxygen with three atoms rather than two, is created by sunlight acting on oxygen. The ozone layer in the upper atmosphere, normally only 3-4m thick, filters out 99% of the sun's harmful ultraviolet radiation. If it was destroyed, life could only exist deep in the oceans. A 1% increase in UV radiation could damage plants and lead to increases in skin cancers and cataracts. Increased UV radiation depresses our immune system and reduces crop yields. Fish would die from shortage of food. If the ozone dropped to half its normal level, as it does over Antarctica, sunbathers could find their skin peeling after 15 minutes in the sun. More cautious 'experts' say prolonged exposure can cause skin cancer, but it is easily diagnosed and curable.

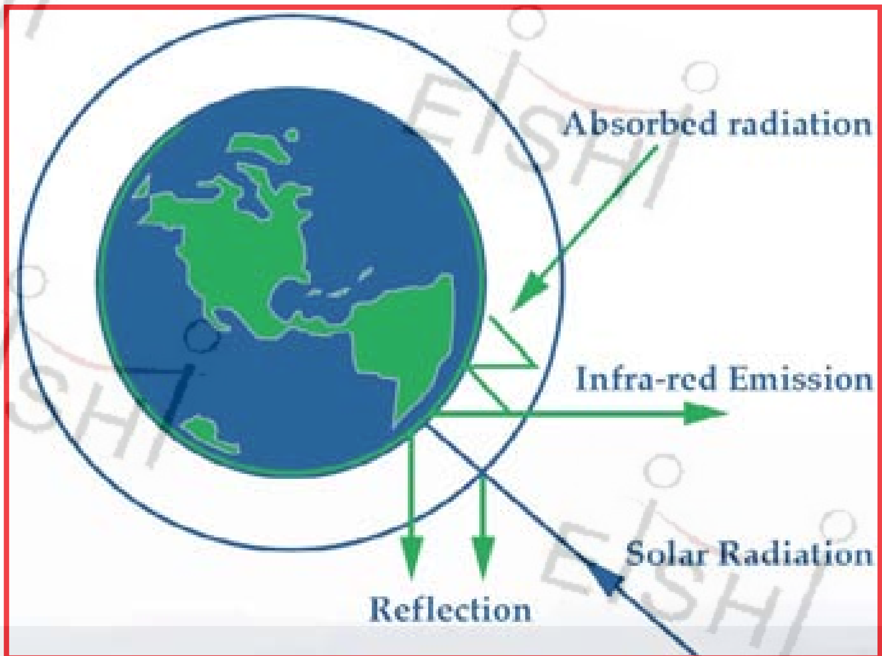
Ozone depletion

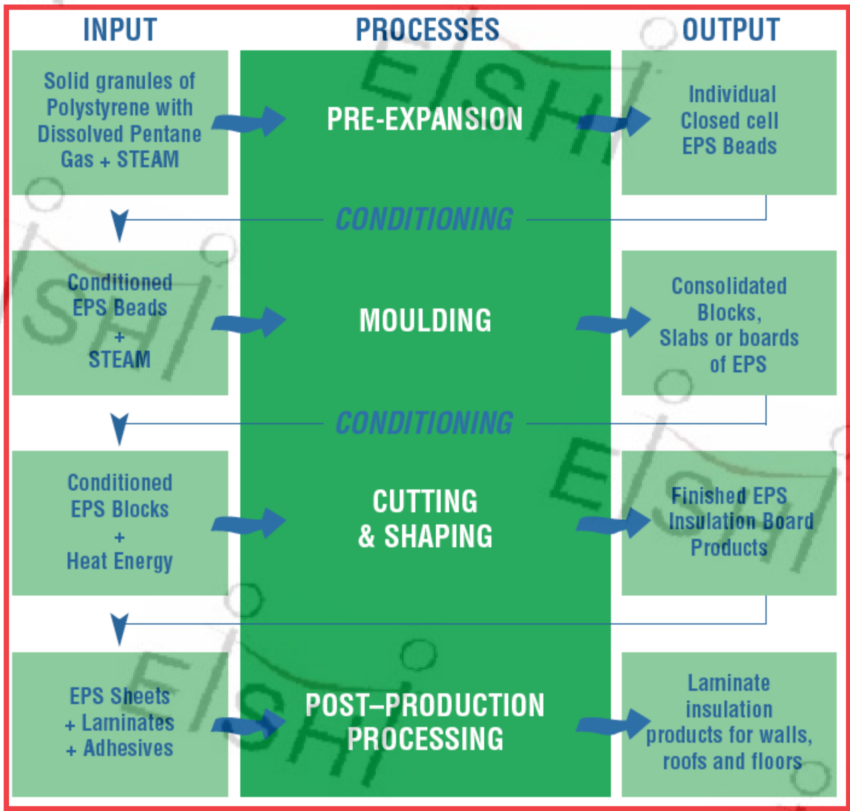
Chlorine catalyses the conversion of ozone to oxygen. One chlorine atom can split 100,000 ozone molecules. Chlorofluorocarbons are thought by most experts to be the primary source of ozone depleting chlorine. Volcanic eruptions, polar clouds, and cleaning and correction fluids play a part. Chlorine from reactions such as wood burning and the decay of wood and seaweed has always been present in the stratosphere. Ozone depletion was first suspected in 1974. Scientists became concerned in 1985 when the British Antarctic Survey reported a thinning of the layer over the South Pole. In 1987 the 'ozone hole' over Antarctica was reported to be as large as the USA, and to extend over some inhabited areas. Reports now indicate seasonal thinning over the North Pole as well. The intensity of sunlight affects the amount of ozone in the stratosphere. It is thinnest over the poles in winter, when there is little daylight. Over the equator there is no seasonal change.

It is now widely accepted that Chlorofluorocarbons (CFCs), and Hydrofluorocarbons (HCFCs) are contributing to the depletion of the ozone layer (Ref.3). The available evidence suggests that such man-made chlorine compounds are responsible for the so called 'ozone holes' – areas of reduced ozone concentration over the polar regions. Ozone levels during springtime over Antarctica are now 60% depleted. Scientific findings have shown that significant ozone depletion is also apparent over large areas of the Northern and Southern hemispheres, particularly during the spring and summer months. CFCs or HCFCs have never been used in the production of expanded polystyrene (Ref.4). However before the Montreal Protocol CFC 11 and CFC 12 were widely used for blowing some other foam plastic insulation materials. In response to the protocol these foam manufacturers switched to HCFCs and sometimes CO_2 or pentane. The phasing-out of HCFCs means that these industries must now find alternative blowing agents. The figure to the left summarises the main alternatives. The latest proposal for a new EC regulation will ban the use of HCFCs completely for foam-blowing from the year 2004 (Ref.5). The specific proposals (Ref.6) are that HCFCs are banned for the production of:

- Extruded polystyrene from 1 January 2002
- Polyurethane sandwich panels from 1 January 2003
- All other foams (phenolic, polyisocyanurate, polyethylene), 1 January 2004.

The effect on these products of having to switch to alternative non-HCFC blowing agents will be an overall reduction in their thermal insulation performance.





Above: The five manufacturing stages of EPS.

How can EPS minimise global warming?

It is clear that to reduce the global warming effect it is essential to burn less fossil fuels. Research (Ref.7) has shown that energy efficiency initiatives in the building sector are amongst the most cost-effective measures available for policy makers seeking to reduce carbon dioxide emissions. Increasing their insulation levels can reduce the energy requirements of buildings.

For refurbishment and new building work the estimated investment cost per ton of CO_2 saved annually is between Euro282 and Euro884 per ton and the lifetime saving per ton of CO_2 saved annually is estimated to be between Euro247 and Euro869 per ton. The return on investment payback period is therefore less than 1 year. Expanded polystyrene is a cost effective and efficient way of insulating buildings.

What is EPS and where is it used?

Expanded Polystyrene (EPS) is a lightweight rigid foam material that is made by the polymerisation of styrene, an oil derivative also found naturally in foods such as strawberries, nuts and beans. The blowing agent employed is pentane which is neither a CFC nor an HCFC. EPS is a versatile durable material that offers excellent insulation properties. As the structure of EPS consists of 98% air its initial thermal properties are maintained throughout its working life. It can be manufactured in a wide range of shapes and sizes. It is non-toxic, moisture resistant and rot proof. EPS is primarily used as an effective thermal insulation material for walls, roofs and floors in a wide range of buildings. It is also used as a packaging material and has applications as a void-forming fill material in civil engineering projects, as lightweight fill in road and railway construction, and as flotation material in the construction of floating pontoons in yachting marinas.

The manufacturing process

Expanded polystyrene insulation products are produced from solid granules of polystyrene. These granules are formed from petrol and naphtha that is derived from crude oil. Naphtha at very high temperatures is rapidly cooled in a steam cracker, to transform it into organic compounds like ethylene and benzene. The combination of these compounds produces ethyl benzene from which styrene, the building block of polystyrene, is produced. Polymerisation of styrene with the addition of an expansion agent (pentane) produces EPS in the form of beads. Pentane is a naturally occurring chemical like methane.

The amount used in the production process does not represent a burden to the environment. Nature quickly converts it to water and carbon dioxide. Much larger amounts of its sister compound, methane are produced during the decomposition of household waste. Despite the small quantities of pentane released, the EPS industry is researching ways to reduce these emissions still further. The process of expanding the solid EPS granules to form perfect closed cells of EPS is achieved by virtue of the small amounts of pentane gas dissolved into the polystyrene base material being expanded under the action of heat supplied by steam to approximately forty times the original volume. The EPS beads are then moulded into appropriate forms suited to their application. There are five manufacturing stages
as shown overleaf in the figure on the left side.

Pre-expansion Polystyrene granules are expanded by free exposure to steam to form larger beads, each consisting of a series of non-interconnecting cells.

Conditioning After expansion, the beads still contain small quantities of both condensed steam and pentane gas. As they cool, air gradually diffuses into the pores replacing, in part, the other components.

Moulding The beads are moulded to form boards, blocks, slabs etc. The mould serves to shape and retain the pre-foam and steam is again used to promote expansion. During moulding, the steam also causes bonding of each bead to its neighbours thus forming a consolidated product.

Shaping After a short cooling period, the moulded block is removed from the machine and after a further conditioning period may be cut or shaped as required using hotwire elements or other appropriate techniques.

Post-production processing The finished product can be laminated with foils, plastics, roofing felt, fibreboard or other facings such as roof or wall cladding sheets.

Environmental credentials of EPS

The environmental effects of the manufacture of the raw EPS-expandable polystyrene bead and the conversion of EPS to insulating material are small compared with those of producing the energy that would be wasted if that insulating material was not employed. During the life cycle of EPS insulation, the main environmental effects are those of substances released into the atmosphere, principally when the raw EPS is made and when the insulating board is delivered to users. The pentane (used as blowing agent) is released during conversion of the raw material to insulating board and has a minimal global-warming potential making only a slight contribution to the greenhouse effect. Expanded polystyrene does not now and never has used CFCs or HCFCs in its manufacturing process, therefore it does not damage the ozone layer.

Energy consumption and saving potential

The table below gives the primary energy required for the manufacture of one cubic metre of EPS. The tabulated values do not include the calorific value of the petroleum from which the EPS is made.

EPS TYPE	DENSITY (kg/m³)	PRIMARY ENERGY (MJ/ m³)	PRIMARY ENERGY (kW-h/ m³)	FUEL-OIL EQUIVALENT Kg	FUEL-OIL EQUIVALENT LITRES
PS 15 SE	15	540	151	12.6	15.1
PS 20 SE	20	680	190	15.8	19
PS 30 SE	30	960	269	22.4	26.9

Depending on the density of the material, the primary energy required for the manufacture of the cubic metre is 151-269kWh, the equivalent of burning 15-27 litres of fuel. This is about the quantity of heat saved in six months or less when that volume of insulating material is used for thermal insulation. Thereafter, energy is saved as long as the building is in use.

Recycling

EPS can be recycled if it is recovered without contamination from other materials. EPS waste can be ground and mixed with fresh EPS to make new foamed products. Alternatively EPS can be melted and extruded to make compact polystyrene, for items such as plant pots, coat hangers and wood substitutes or medium toughened polystyrene, for products from which sheet or thermoformed articles such as trays can be made. As part of a mixed plastic waste, EPS can be recycled to make, for example, park benches, fence posts and road signs, ensuring the plastic waste has a long and useful new life.

Conclusion

In the closing decades of the last century, the world learned some hard environmental lessons. As we start the new century we know that, unless the worst effects of climate change are countered, then people all over the world face more frequent severe weather conditions, rising sea levels and devastating floods, together with their growing economic and human costs.

Scientists tell us that we must begin to reduce greenhouse gases now to avoid the worst consequences. The world has started to face up to this challenge. The worst effects of climate change can be avoided if we all start to cut emissions now, and in time stabilise the levels of carbon dioxide in the atmosphere. This is a major challenge and its scale cannot be underestimated.

Expanded polystyrene as an efficient and effective thermal insulation material can play its part in reducing carbon dioxide emissions and make a very positive contribution to the alleviation of global warming. No CFCs or HCFCs foaming agents are used in its manufacture, so EPS causes no damage to the ozone layer. The energy used in its manufacture (embodied energy) is recovered within six months by the energy saved in the buildings in which it is installed. For the remainder of the life of the building, the EPS reduces its energy requirement thereby requiring the combustion of less fossil fuel which results in less CO_2 being generated.

At the end of its useful life it can be recycled or the thermal energy contained within can be recovered by incineration in suitably designed Waste to Energy Plants to provide energy for district heating or the generation of electricity. EPS can therefore make a positive contribution to the overall world environment.

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