European Isocyanate
Isopa
Producers Association

POLYURETHANES: SUSTAINABLE MATERIALS

BING

ONE voice

EUROPUR

WHAT ARE POLYURETHANES ?

By mixing the chemical raw-materials - polyols and diisocyanates in carefully formulated proportions and using transformation processes, ranging from the simple to the sophisticated, it is possible to make a wide variety of polyurethanes, including rigid and flexible foams.

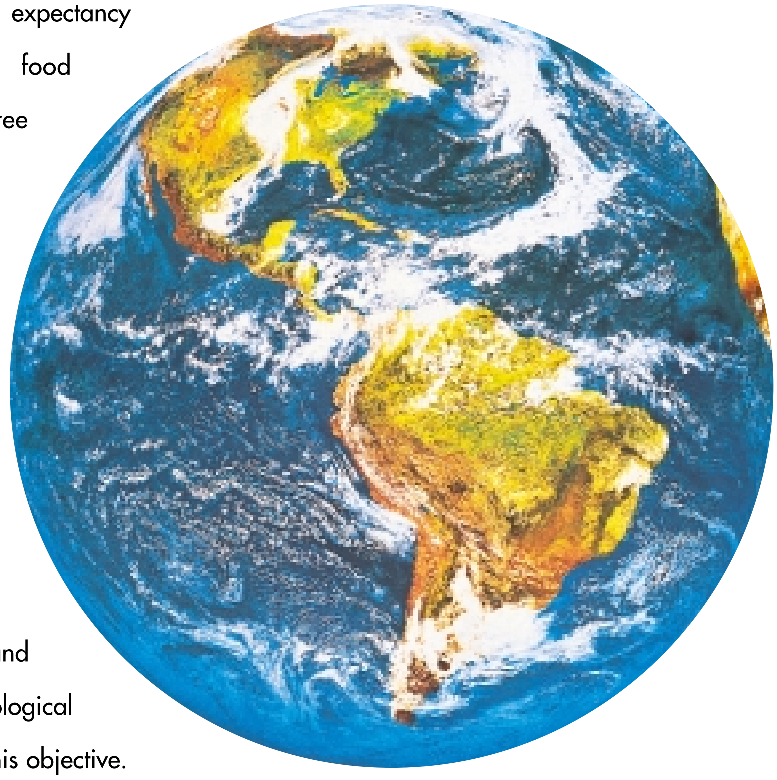
Polyurethanes have revolutionized the quality of life in the 20th Century, providing energy savings, safety, lightness, comfort and durability. Combining the skills of the designer, chemist and engineer, their unique properties can be adjusted to create valuable products varying in structure from soft furniture foam to tough car bumpers, each tailor-made for a specific purpose.

Polyurethanes are durable products, offering many years of service. Lifetimes can vary between 3 and more than 50 years depending on the end use. An average lifetime of 15 years for refrigerators (insulated with polyurethane foam) is just one example.

Usually used in combination with materials such as textiles, metals, wood and other polymers, polyurethanes are not always visible in the end-product. And yet most of us make use of them every day in cars, furniture and bedding, refrigerators, in building insulation and heating systems.

ISOPA, The European Isocyanate Producers Association, together with BING, EUROPUR and PANAMA, associations which represent the European polyurethanes industry, is committed to ensure that the manufacture, use and recycling/recovery of these products are fully understood. This effort is to be seen in context with ISOPA's continuous strive towards sustainability.

SUSTAINABLE DEVELOPMENT



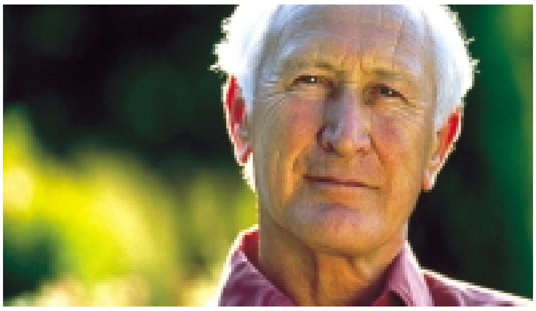
Population growth, improved life expectancy and the growing need for food and shelter represent the three major factors affecting the planet's resources. Sustainable development can help to bend the steep upwards curve by introducing solutions which minimize resource needs over time, while increasing the quality of life and maintaining a viable economy. Multi-purpose materials, goods and services using the latest technological developments can help achieve this objective.

Advanced concepts, such as design for durability, lightweight, recycling and recovery, introduce a multiplying effect that improves resource efficiency to a level that can never be reached by addressing each of these performance parameters alone.

Polyurethanes, because of their versatility are materials of choice which can satisfy multi-purpose design objectives. They can be tailor-made to fit into applications where advanced performance standards respond to the expectations and needs of sustainable development.

THE TRIPLE JUMP

Over the past 50 years three major evolutionary steps for mankind *"The Triple Jump"* have occured. They have profoundly changed the face of the world and have critically influenced the behavioral patterns of people living on Earth.



Population Growth: With a doubling of the world population from 2.5 to 6.0 billion people in 50 years and an expected 8 billion inhabitants by the year 2030[1,2], the world has an ever increasing number of inhabitants to *shelter, feed and occupy.*

Essentials of Life: The need for food, fresh water, fuel and shelter. Global food production and housing have increased, (meeting the per capita food requirements in most countries) and more people than ever before have access to fresh water. Accompanying these changes is the loss of crop and grazing land, fishing grounds, forests and renewable supplies of fresh water, all of which continue to diminish at a high rate[1, 3, 5 #].

Life Expectancy: Developments in hygiene and medicine have extended life-expectation beyond the dream of our grandparents; from a world average of 48 years in 1950 to 66 years today and a projected 73 years by 2025 [3, 4].

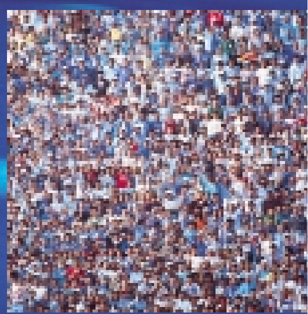
As a result, our demands on the planet earth as the sole source for raw materials to match the increasing demands of human needs and activities, continue to grow.

The interrelationships of the three evolutionary steps are evident (*Figure 1*). Addressing and managing the needs of the world's population against the resources of the planet are at the basis of a *Sustainable Development* in the future. It will require appropriate skills to balance the economic, ecological and social aspirations of mankind.

[#] The FAO[5] estimate that 24 billion tonnes of topsoil are removed each year, while UNFPA[1] report that 7 million hectares of crop and grazing land are lost to erosion, desertification and salification each year. FAO also report that 40% of the world's population rely on fuel wood as their main source of energy, 180 million hectares of forest were lost in the last 15 years, and 70% of the marine species of fish used for food have reached or exceeded sustainable levels.

Figure 1. 'The Triple Jump'

Introducing sustainable development as a new scheme of doing things, different from the one we have been used to, will impact directly on the materials and services that mankind will require over the next decades. This new way of doing things will have to be matched and optimized against the following considerations:



The ecosystem composed of air, water and soil. Threats on the ecosystem are:

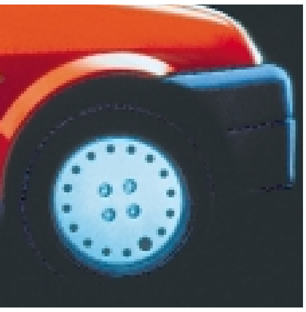
- air: ozone depletion and global warming;
- water: shortage (and pollution) of fresh water resources;
- soil: salification, acidification and erosion.

The availability of the world's natural 'capital' of:

- Minerals
- Fossil resources, such as oil and natural gas
- Biodiversity
- Renewables
- Oxygen

SOLUTIONS

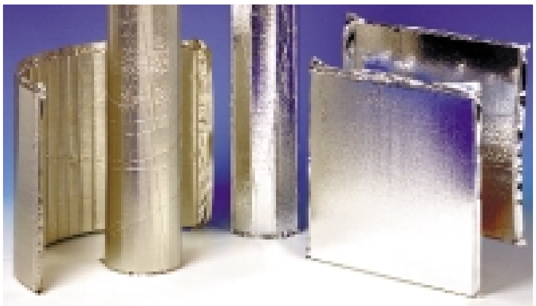
The Plastics Industry has the versatility and benefits of goods and articles made from fossil resources, such as oil, gas and coal, or renewable resources, such as starch and sugar. We can offer favorable solutions to mitigate many of the threats imposed by future potential resource deficiencies. Although using up some resources, these materials, after a useful life, can either be recycled or can be recovered as a fuel, thus avoiding the separate extraction and processing of, for instance, oil.



In terms of resource depletion, it is known that polyurethanes use up some ten percent of the worldwide chlorine production to manufacture the major intermediates. The truth is that after having contributed to the low energy consuming production steps of these intermediates, the chlorine is brought back as an inert salt, to be picked up by the sea and the natural material cycle[6].

Polyurethanes in particular, through their unique composition and related properties, display the following attributes[8,9]:

Insulation capacity in housing, transportation, refrigeration, heat transport and other, thus avoiding unnecessary emissions to compensate for energy losses in case of lack of insulation.



Food preservation throughout an efficient cooling chain by saving as much as fifty percent of valuable food that would otherwise rot before it is consumed.

Durability in construction, cars and refrigeration. Products using polyurethane materials can last longer. This avoids unnecessary replacement, which would use up resources on a broader scale.

Lightweight. Ranging between 30 to 50kg/m^3 density, polyurethane foams use up a minimum of raw material to satisfy specified requirements and standards. For example this helps in the production of lightweight vehicles, saving fuel energy.

Renewables. Although generally only based on renewable resources by a fraction, polyurethanes offer outstanding characteristics to bind and shape articles that are mostly made from renewables, such as wood chips or plant fibres - a synergy which has wide future perspectives.

THE DETAILED FACTS

Polyurethane Production

Life-cycle analysis (LCA) carried out on the polyurethane raw materials (MDI, TDI and polyols) and extended to the polyurethane articles (flexible and rigid foams) delivers unambiguous energy, material and emission figures[6,7]. *(Figure 2).* It follows that polyurethanes are comparable with many other plastic materials on a unit weight produced basis. Hence, when applied to low density foam, they need less resources per unit volume. These materials can either be recycled after use or their energy content can be recovered, thus releasing the inherent energy "borrowed" to provide the better heating and shelter[10, 11].

Insulation

The insulation efficiency of polyurethane foams is a key property for the low temperature preservation of food during processing, storage and distribution to the consumer. In a key application, polyurethane foams also provide house insulation and ensure a preservation of the human habitat against heat and cold.

Figure 2. Energy Expenditure in Perspective

Polyurethanes		Comparison
Polyurethane raw materials Polyol/MDI	approx 100MJ/kg	As many other organic chemicals
Processing PUR foam	2-6 MJ/kg*	Thermoplastics 6 to 29 MJ/kg
Transport (200km) PUR foam	approx. 2MJ/kg*	As other bulky goods
Packaging PUR foam	approx. 5MJ/kg*	As other bulky goods

*preliminary data

Figure 3. Polyurethanes in the Food Chain

Insulation of Agricultural buildings | Food Processing Factories

↓

Refrigerated transport
Cold stores
Refrigerated transport
Supermarket cold rooms and display units

↓

Domestic refrigerators and freezers | Portable insulated boxes

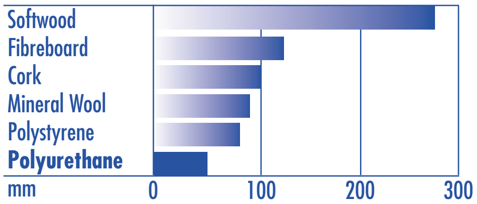
Insulation in the Food Chain

From insulating animal sheds to distribution of refrigerated containers via storage in cold stores, to local storage in supermarkets, and ending in domestic refrigerators, freezers or portable coolers, insulating foam plays its role. Polyurethane foam is not only a versatile material which exhibits desired processing characteristics such as toughness, it also offers a unique combination of lightweight and closed cell structure with encapsulated insulating gas. This is the primary reason for its very favorable insulation to thickness ratio, which saves space and material while achieving the required insulation values *(Figure 3).*

In Construction

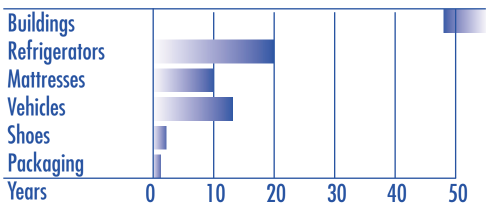
Today, about 45 percent of fossil fuels are used to cool and heat the interiors of buildings and homes.

Figure 4. Thickness of materials to give same level of insulation



Through the use of insulation materials, considerable energy savings are achieved. This results in a substantial reduction of CO_2, one of the main contributors to global warming[12]. Polyurethane rigid foam, now CFC free, is one of the best available insulation materials for the construction of new buildings as well as for the renovation of existing buildings *(Figure 4)*. It is true that polyurethane materials will use up a finite amount of energy for their production as was researched in the LCA work. However, when compared to the energy savings during use, the cumulative yearly energy saving far outweighs the initial, once only, energy input *(Figure 5)*. Considering that much of the "borrowed" energy of these materials can be recovered after use, the resource loop is virtually closed.

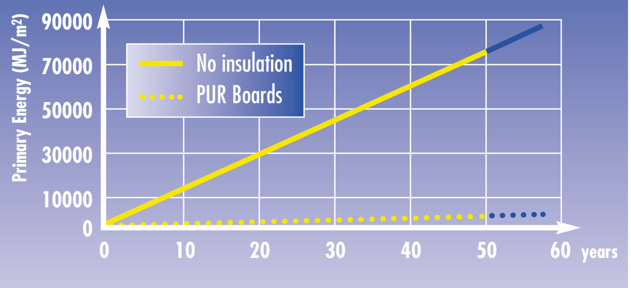
Figure 6. Average life-span of polyurethane containg articles



Durability

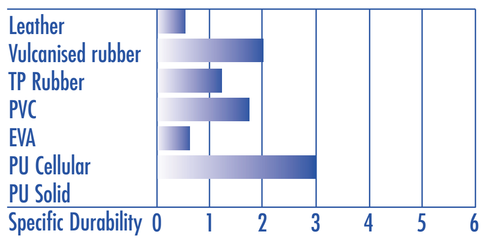
The winning materials over the next decades in terms of minimizing resource consumption will have to be durable. Indeed, in many cases the impact on soil, water and air can be much reduced, provided that the materials and articles, designed for a specific purpose and use pattern, become optimized in terms of service life to match the human needs. The life-span of polyurethane containing products can reach 50 years (and more) depending on their use and their application, *(Figure 6)*. In the case of shoe soles for instance the durability of polyurethanes are equal to or exceed those of other comparable materials *(Figure 7)*.

Figure 5. Roof insulation, New building : Energy Balance over service life



Note: The energy savings during use far exceed energy used in production, and can hardly be displayed on the scale used.

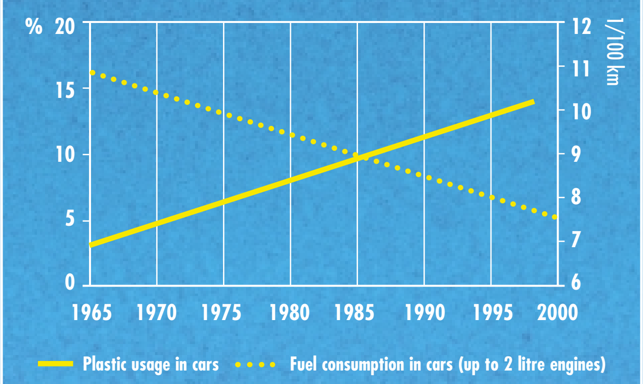
Figure 7. Durability of shoe sole materials



Lightweight

Plastics materials, particularly polyurethanes, used in cars have grown substantially over the past 20 years because of their ability to provide safety, comfort and durability, whilst reducing weight in comparison to other materials[13]. Today, seats in cars are made from lightweight polyurethane because this low density material represents the best choice to meet the diverse requirements and expectations from car manufacturers and consumers (low weight, high durability, favorable cost). The choice of polyurethanes is highly desirable since the reduced fuel consumption which plastic materials bring during a car's lifetime greatly reduce CO_2 (and other gas emissions) which can have an impact on air pollution and on global warming *(Figure 8)*.

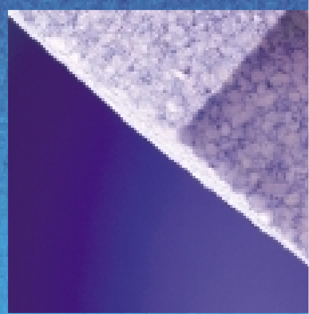
Figure 8. Energy consumption in cars



The same arguments are valid for all applications where energy (fuel) is being consumed in moving an object from point A to point B. In transportation, weight saving means fuel saving, and polyurethane foams through their low densities (30 - 50 kg /m^3) can substantially contribute towards this goal.

A balanced way forward

This document displays the benefits which are linked to the usage of polyurethanes, described as sustainable materials, through features such as insulation, durability and light-weight. It does not intend to mitigate that the production of these materials relies on energy and other resources, as displayed in the LCA research work[6,7]. It does however, take into consideration that the chemical industry is dedicated to reduce production and use related impacts, such as emissions, wastes, ozone and resource depletion. The polyurethanes industry, which is committed to the same reduction targets, will continue to carry out a balanced performance assessment of its product portfolio, with the objective to have the benefits outweighing more and more the potential environmental impacts.



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European Isocyanate
ISOPA
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ISOPA Members

BASF
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ISOPA works closely with

APME

(Association of Plastics Manufacturers in Europe)
and the European Polyurethane Industry Associations

BING

Federation of European Polyurethane Rigid Foam Associations

EUROPUR

European Association of Flexible Polyurethane Foam Blocks Manufacturers

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ISOPA, the European Isocyanate Producers Association - is a non-profit making organization operating as a sector group under the auspices of the European Chemical Industry Federation (CEFIC), adhering to the federation's operational policies and codes of practice, including the Treaty of Rome. Its activities are supported by high level research, much of which is sponsored by the International Isocyanate Institute.

Since the original polyurethane material has not been designed for use in articles in contact with food, relevant EU (such as Directives 90/128/EEC) and national legislations need to be consulted, if and when recycled materials are used to manufacture articles and goods for possible direct and indirect food contact.

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