Polyurethanes in cars - Summary

Polyurethane is a highly versatile material that is commonly used in the automobile industry because of the many economic and ecological benefits it provides:

**Efficiency:** Polyurethanes can be tailor-made to meet the exact shape and size requirements, thereby reducing the generation of scrap material and lowering vehicle costs.

**Sustainability:** Polyurethanes are often applied as lightweight foams which help reduce the weight of cars, thereby lowering fuel consumption and CO₂ emissions.

**Recyclability:** At the end of their useful life, polyurethanes can be recycled and their energy recovered through a range of approved technologies.

**Versatility:** Polyurethanes are an extremely versatile material which makes them ideal for a range of applications in cars, from foam seat fillings to bumpers and steering wheels.

**Safety:** The shock absorbing qualities and high resilience of polyurethane foams ensure the safety of drivers and passengers in cars, under static and dynamic conditions.

As an industry, we are committed to optimising recycling within the boundaries set by the markets for recyclates, and support the landfill reduction targets put forward by the European Commission.

The European Isocyanate Producers Association (ISOPA) strongly supports the use of carefully controlled incineration to convert polyurethane waste into valuable energy when local conditions favour it.

**To achieve this, we work to:**

- increase the awareness of the ELV issue along the value chain and amongst other stakeholders
- ensure there is an informed understanding of polyurethanes in the application of the ELV Directive
- support those recovery options most favoured by ecological, economic and logistic considerations within an integrated waste management strategy taking local specifics into account

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**PLASTICS DISTRIBUTION IN AN AVERAGE CAR**

![Graph showing plastics distribution](source: APME - 'Plastics - a material choice for the automotive industry')
THE IMPORTANCE OF POLYURETHANES IN CARS

Today’s key objective for the automotive industry is to develop cars which are clean, safe, energy-efficient and affordable.

Polyurethanes combine lightweight and flexibility with great strength and durability. Their versatility is instrumental in achieving the precise mechanical properties required for specific applications.

A typical car of 1000 kg total weight contains 100 kg of plastics, of which about 15 kg are polyurethanes. Car manufacturers recognise that, by choosing polyurethanes, they can significantly improve the quality, safety and cost-effectiveness of modern cars, and increase their technical, environmental and economic performance at the same time.

The Main Applications are:

1. Seat foam
2. Cushion overlay (fabric backing)
3. Carpet backing
4. Door panels
5. Sound absorption and vibration dampening
6. Dashboards
7. Steering wheels
8. Bumpers
9. Energy absorbers
10. Headliners
11. Airbag covers
12. Window encapsulation

Polyurethanes, one of the most versatile group of plastics, are used in a wide range of applications. They are made from two basic raw materials: polyols and polyisocyanates, which are measured and mixed to form solid polyurethanes or various types of foams.

Polyurethanes are unique materials in the automotive industry because specific combinations of raw materials can be chosen to tailor the desired end-product. This enables designers and car manufacturers to adjust the material properties to meet the exact performance demands and fulfil the quality requirements for specific end-use applications.
Polyurethanes are Sustainable Materials - Their Benefits in the Automotive Industry are Unmatched

Polyurethanes are lightweight materials: Polyurethane applications lower the environmental impact of cars by reducing vehicle weight. This improves fuel efficiency and lowers emission levels. In the last five years the density of polyurethane for major applications has been reduced by 30 to 40 per cent while still maintaining the same mechanical properties. Seating foam, for instance, has one of the lowest densities of any plastic material used in a car: 0.03 to 0.05 g/cm$^3$. Polyurethane foam in headliners is another good example with a density of 0.02 to 0.04 g/cm$^3$.

Polyurethanes reduce noise for passengers: The excellent sound-absorbing and vibration-dampening qualities of polyurethanes contribute to higher comfort and safety levels. Polyurethane sound insulation can reduce vehicle noise by more than 50 per cent in comparison with traditional insulation materials such as bitumen sheet or fibre felt.

Polyurethanes provide safety and comfort: The excellent shock absorption properties of polyurethane in, for example, bumpers and dashboards ensure the safety of drivers and passengers, while high resilient foams in seats provide comfort under static and dynamic conditions.

Polyurethanes provide durability: Polyurethanes are not prone to corrosion. Throughout their life, they ensure stability even under severe conditions.

Polyurethanes are versatile: They offer engineers a wide choice of performance and processing characteristics, allowing applications to be tailor-made into advanced shapes and forms using the same basic chemicals. This contributes to lower vehicle costs and reduces the generation of scrap material.

Polyurethanes increase freedom of design: The versatility of polyurethanes, combined with their excellent qualities of comfort and strength, enables designers to develop, for example, car seats adapted to the design of the car which provide optimal support to the occupants.

Polyurethanes are recyclable: They can be recycled through a range of approved technologies. In 1997, more than 100,000 tonnes were recovered and recycled in Western Europe, predominantly from the production of polyurethane for furniture and mattresses, but around 10 per cent is from polyurethane used in cars, including approximately 5000 tonnes taken from ELVs.

Polyurethanes offer the potential for monomaterial solutions: Several applications, such as seats, dashboards, sound insulation, bumpers and doorpanels, can be designed using polyurethanes only (the monomaterial concept), thereby facilitating recovery and recycling.

Polyurethanes are indispensable: On the basis of the weight / performance ratio, polyurethane is very often the best available material for use in cars. Efforts to substitute polyurethane foam, for example in seats, have often failed because either the weight of the alternative material was too high and/or the car seat would not last as long as the car.
Over two million tonnes of polyurethane raw material are produced every year in Europe alone. In monetary terms this equates to some three billion euro (six billion DM). More than 15,000 European companies, with about 800,000 employees, are involved in the manufacture of polyurethane and its products.

In 1997 alone, more than 300,000 tonnes of polyurethanes were used in applications in Western European cars. This represents a value of approximately one billion euro in the form of finished car parts.

When assessing the environmental performance of a car, its total environmental impact must be taken into account throughout the whole life-cycle: from “cradle to grave”. As studies indicate, more than 80 per cent of the life-cycle energy of a car is derived from fuel consumption. The first priority, therefore, must be to reduce fuel consumption and to lower emissions. Polyurethanes contribute to achieving this goal, because they have relatively low energy consumption in the production process, thereby saving natural resources. In use, their light-weight results in further significant reductions in fuel consumption and emissions – an important contribution to reducing global warming.

The increased use of plastics has already given weight-saving benefits - and this should be further encouraged. For example, a calculation by APME (the Association of Plastics Manufacturers in Europe) demonstrates that 100 kg of plastics in a modern car have replaced 200-300 kg of conventional materials, decreasing fuel consumption by 750 litres over a 150,000 km life-span.

This significant improvement ‘per car’ translates to a total annual reduction in oil consumption of 12 million tonnes in Europe and consequently, a drop in CO$_2$ emissions of 30 million tonnes. In fact, using more plastics in cars has offset the environmental impact caused by the added weight of more parts to provide extra comfort, safety and durability, such as steel safety cages.

**Polyurethanes are Sustainable Materials**
- They have a relatively low energy consumption in the production process
- They help to lower vehicle weight
- They help reduce fuel consumption and emissions
- They are recyclable
End-of-Life Vehicles

The life-span of a car varies from country to country. The automotive industry estimates that the average lifetime of a vehicle is about 12 years. The majority of the materials from an End-of-Life Vehicle (ELV) can be removed and recycled. The larger parts suitable for re-use or mechanical recycling are dismantled while the remainder is shredded. Following the removal of the ferrous metal fraction - about 75 per cent of total vehicle weight - the remaining residue is known as Automotive Shredder Residue (ASR). ASR is still disposed of in landfills. Given there are 10 million ELVs each year, the volume of ASR forms a noticeable part of the total waste stream and should be diverted from landfill.

Within the framework of the European Waste Management Policy, the European Commission has drafted a new directive on the take-back and treatment of ELVs to reduce the quantity and hazard associated with ASR from ELVs. Under the heading of “Environmentally Sound Waste Management”, this proposal aims to ensure a safe treatment and recovery of cars at the end of their life. Moreover, the proposal is designed to prevent the dumping of vehicles in the environment, to save landfill capacity and to increase energy savings.

ISOPA recognises that landfilling ASR is not a sustainable solution and is constantly working to develop new options for recovering and recycling polyurethanes from ELVs.

The flexibility of polyurethanes enables designers to improve the technical design of cars to facilitate recovery and recycling techniques and, once reclaimed, the polyurethanes can be recycled through various well proven techniques, thereby reducing the amount of ASR that goes to landfill.

ENERGY CONSUMPTION FOR A PASSENGER CAR

- Manufacturing (total) 7.1%
- Recycling potential (without plastics) 8%
- Recycling potential (plastics) 1%
- Use and maintenance 87.1%
Polyurethanes are recyclable through a range of different methods. There are varying external factors, however, that should be considered when determining which recovery option is preferable in relation to ecological considerations and technical/economical feasibility. Examples of such factors are local conditions, market capacities for recyclates and the amount of reclaimed material available.

**Mechanical Recycling**

Polyurethanes are always used in composite parts. The polyurethane needs to be segregated before it can be mechanically recycled. Most dismantling and segregation from other materials needs to be carried out manually making it a costly and labour-intensive process.

Dismantling a seat, for example, involves a number of complex steps such as the removal of the textile cover and metal inserts. The incorporation of airbags and their sensors will add an additional cost penalty to seat foam recuperation. Reclamation of foams from ELVs in most cases, therefore, cannot compete on a cost basis with production scrap that is already on the market. These cost factors need to be taken into account to assess the economic viability of mechanical recycling.

**Important examples of mechanical recycling are:**

- **Rebonded flexible foam**: There is a substantial market for rebonded foam made from pieces of shredded flexible foam. It has been used for many years, as its relatively high density and excellent loadbearing capacity make it suitable for applications, including vibration sound dampening, flooring, sports mats, cushioning, packaging and carpet underlay.

  Every year, 25,000 to 30,000 tonnes of flexible polyurethane foam, mainly furniture production scrap and, in addition, approximately 5,000 tonnes from ELV seats, are recycled into rebonded foam. Another 60,000 tonnes/year are exported to North America for the same recycling process. Together these markets are not large enough to accept the total seat foam from ELVs in Europe, an estimated 50,000 to 70,000 tonnes/year. Forcing these amounts of additional waste into the existing market by means of subsidies would clearly have a negative effect on all suppliers of the current production scrap (trim foam) many of whom are small and medium size enterprises.

- **Powdered flexible foam**: A range of grinding techniques has been developed for various polyurethane materials. Depending on the size of the particles, the polyurethane can be recycled for re-use as filler for new flexible foam. This technique is used to recycle production waste to the order of 1000 tonnes per year at particle sizes of 100 micrometers.
Various polyurethane processors are evaluating glycolysis technologies, either on a pilot or on a commercial scale. The recycled polyols obtained from glycolysis processes fulfil the requirements of some niche applications. Glycolysis, therefore, complements mechanical and feedstock recycling.

Glycolysis is a liquefying technique for polyurethanes in which basic building blocks can be recovered and used to produce new polyurethanes. Different types of polyurethane require tailor-made glycolysis processes. These techniques are particularly appropriate for recycling production waste. They are applied commercially for a range of applications, using over 1,000 tonnes/year polyurethane scrap.

In the automotive field, the use of glycolysis polyols amounts to about 200 tonnes/year: for example, glycolysis is used for the recycling of the trimmings from the all-polyurethane dashboards of a German car manufacturer.

Although any kind of polyurethane can be glycolysed, the glycolysates obtained are not always easy to market. Also, the amount of glycolysates is always larger than the amount of waste consumed by the process. Glycolysis alone, therefore, cannot solve recycling problems.

Feedstock recycling is a technology used for recovering value from large quantities of post consumer and industrial plastics waste. Essentially, the process involves recovering hydrocarbons from mixed plastics waste and feeding them back into the petrochemical manufacturing chain as feedstock materials.

The waste plastics are heated and melted down into liquid and gaseous hydrocarbons from which oil and gas products can be recovered. These are re-used as raw materials (feedstock) in chemical or petrochemical processes to produce a variety of different products.

Polyurethane materials in a mixed plastics stream can be successfully incorporated into many of the existing feedstock technologies. ISOPA sees feedstock recycling as an important future option to absorb increasing amounts of mixed plastics waste streams all over Europe.
Energy Recovery

Energy recovery is the process of recovering the fossil fuel energy contained in polymers (which are all based on oil) through direct incineration with or without other waste materials. The recovered energy is used to provide heat or electricity to industry and homes. Polyurethanes have a recoverable energy value comparable to that of coal.

Recycling alone cannot solve the ELV waste problem. Additional recovery options are needed, in particular for those parts which are small, light, mixed with other materials and difficult to dismantle. Energy recovery is an ecologically sound way to treat ELV waste. It is also a technically proven and effective way of recovering the ASR that remains after the plastic parts, which can be recycled cost effectively, have been removed from the vehicle and which would otherwise have been sent to landfill.

If incineration with energy recovery is used to replace energy which would otherwise have been generated from burning fossil fuels, plastics waste incineration does not produce any additional CO₂ emissions.

Energy from ASR can be recovered through combustion with household waste in Municipal Solid Waste (MSW) combustors, or with fuels in cement kilns.

Options currently used for polyurethane recovery are:

- mechanical recycling
- chemical recycling
- feedstock recycling
- energy recovery


**Oil usage in West Europe**

- **Oil 100%**
- **86% Utilisation of energy content**
- **Polymers 4%**
- **Material recycling**
- **Other uses 10%**

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**Municipal Solid Waste Combustion**  
Combustion of mixed plastics with MSW or with traditional fuels is known as ‘co-combustion’. Modern state-of-the-art MSW combustors operate in a safe, efficient, and reliable way. Effective equipment (known as scrubbers) prevent pollution to the atmosphere and help meet the stringent European emission requirements in force since June 1996.

**Clean fuel combustion**  
There is a specific opportunity to use the clean polyurethane waste stream as a fuel substitute in cement production. The growing awareness of global warming, the relatively large contribution of the cement industry and their objectives to reduce their impact as well as resource conservation and future higher costs of energy, make fuel substitution an industry priority.

Polyurethane waste from ELV seats is, therefore, considered to be a very suitable alternative fuel in the cement industry.

ISOPA and the EUROMOULDERS are investigating the use of polyurethane seat materials from ELVs as a clean fuel in cement kilns. The objectives of the project are to optimise the pre-treatment cost, to evaluate the best cement kiln option and to measure the viability of the available technology to demonstrate the Fuel Concept at a large scale.
ISOPA supports an integrated approach to waste management for all plastic products. To achieve the maximum environmental and economic benefits from plastics, ISOPA supports an integrated approach to waste management for all plastic products. This means choosing the most appropriate combination of waste management options, adapted to the individual local and regional conditions, with the overall aim of preventing plastics products from going to landfill at end-of-life. The optimal route for re-use, recycling or recovery will be different for each of the various polyurethane application areas in cars and may vary for different regions in Europe. The mix between materials recycling and energy recovery, therefore, must be flexible and adjusted to the local and regional circumstances.

Life-cycle analysis studies of cars indicate that the biggest environmental impact comes from the use-phase of the car. Therefore, simply focusing on the waste treatment, without taking the whole life cycle into consideration, may not always be beneficial to the environment.

Energy recovery provides an attractive alternative to those quantities of polyurethanes that cannot be recycled as a material in an ecologically sensible way. It would not be ecologically sensible, for example, if a front seat cushion made from rebonded foam, weighing approximately 2 kg - which represents an increase of approximately 50 per cent above an equivalent seat cushion from virgin foam - would be applied just because dismantled foam from ELVs must fulfill a certain recycling quota. In this example, recycling may have saved approximately one kilogram of resources during the production of one car. But during the use of the car the additional resource consumption may amount to three kg - a net wasting of two kg.

Mechanical recycling costs are significantly higher compared to the thermal recovery costs of polyurethanes in multiple material parts, such as dashboards. In these cases, energy recovery is the most effective way of disposing of the ASR which remains after all the recyclable plastic parts have been removed from the vehicle and otherwise would have been sent to landfill.

The disposal of polyurethane products through controlled landfill is considered by the polyurethanes industry as a last option if there are no possibilities to viably recover resources.
JOINT INDUSTRY INITIATIVES

To improve the options for recovering most of the plastics from ELVs, the plastics and automotive industries are working together at European, national and international levels and in collaboration with other partners to develop a range of complementary recovery options. At a European level, the following are actively involved in improving the recovery and recycling of ELVs.

Through ISOPA

Recycling Resource Group
The seven ISOPA member companies, together with representatives of major PU trade associations, meet regularly to discuss proactively waste management and recycling issues and to seek the open dialogue with legislators, other industry associations, and downstream organisations. The aim is to speak with one voice and to develop solutions on an industry basis in the area of recovery and recycling of polyurethanes.

In conjunction with ISOPA, the EUROMOULDERS Association is effectively conducting co-research in order to develop sound industrial solutions to the problems that will arise from the compliance with the ELV directive.

Both EUROMOULDERS and ISOPA are convinced that, after a long lasting utilisation (i.e. 8 to 12 years in a car), polyurethanes can be partially recycled into new applications, if economically justified. Otherwise they should be considered as special combustibles in cement kilns or modern incinerators to recover the energy.

Through APME

(Association of Plastics Manufacturers in Europe)

Automotive Task Force
ISOPA is an active player in the Automotive Task Force of APME. This cross industry initiative has been set up to support research and development, looking at the scientific, technical, environmental and economic aspects of End-of-life vehicles.

The European Thematic Network
ISOPA is closely involved in the ‘European Thematic Network’ (ETN), a project group which has recently been set up to assist the effective and full-scale eco-efficient treatment of plastics in ELVs in the European Union. The ETN is supported financially by DG XII of the European Commission.

The objectives are to improve co-operation among the involved industries and create conditions of synergy across Europe. The project includes over 40 partners and is expected to last over 24 months. Next to leading car manufacturers and their plastics suppliers, the network also includes dismantling and shredding industries, material recovery industries, end-users of recovered materials and energy, and the academic and research community.
ISOPA

ISOPA - the European Association of Isocyanate Producers - is the European trade association for the producers of diisocyanates, one of the materials used in the production of polyurethanes.

ISOPA was founded in 1987 by seven chemical companies that have European interests in the production of raw materials for polyurethanes: BASF, Bayer, Dow Europe, EniChem, ICI Polyurethanes, Lyondell Chemical Europe and Shell International Chemical Company. It has taken the lead in representing the polyurethanes industry on important issues, in co-operation with other industry bodies as EUROPUR, EUROMOULDERS and BING.

Following the principles of Responsible Care, ISOPA concentrates on health, safety and environmental issues. ISOPA has developed guidelines emphasising the responsible management of diisocyanates throughout their entire life-cycle.

EUROMOULDERS ASSOCIATION

Ten manufacturers of moulded polyurethane parts for the automotive industry and a number of associated members are representing a major part of the supply chain to this important European Industry. They meet regularly to find solutions to common problems related to recycling and environmental issues, through co-operation, consultation and research projects.

The EUROMOULDERS Association is composed of the following member companies: Recticel (B), Bertrand Faure, Dunlopillo, Treves (F), Fehrler, Johnson Control, Woodbridge (D), Toscana Gomma, Clerprem (I), Grupo Copo (E) and a number of associated members, i.e. raw material suppliers and machinery manufacturers.
ISOPA has produced a series of fact sheets on polyurethane recycling options - the following titles are available:

- PU in Perspective
- Densification/Grinding
- Rebonded Flexible Foam
- Adhesive Pressing/Particle Bonding
- Regrind/Powdering
- Compression Moulding
- Chemolysis
- Feedstock Recycling
- Energy Recovery
- Energy Recovery from Flexible PU Foams
- Recovery of Rigid Polyurethane Foam from Demolition Waste
- Options in Practice
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.

The information contained in this publication is, to the best of our knowledge, true and accurate, but any recommendation or suggestions which may be made are without guarantee, since the conditions of use and the composition of source materials are beyond our control. Furthermore, nothing contained herein shall be construed as a recommendation to use any product in conflict with existing patents or legislations covering any material or its use.

ISOPA Members

BASF
Bayer
Dow Europe
ICI Polyurethanes
EniChem
Shell International Chemical Company
Lyondell Chemical Europe

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

EURPUR
European Association of Flexible Polyurethane Foam Blocks Manufacturers

EUROMOULDERS
European Association of Manufacturers of Moulded Polyurethane Parts for the Automotive Industry

E.P.P.F.
European Profiles and Panels Producers Federation

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