



PURE FACTS

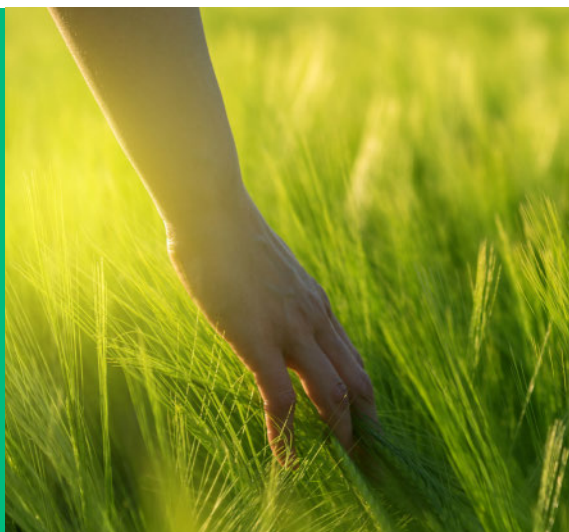
Polyurethane and
sustainability



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People, Planet, Profit: Why sustainability?

Sustainability is a buzzword people have got tired of hearing, because everybody is talking about it. But even though sustainability or sustainable development is an overused and occasionally misused term, its significance cannot be disputed in view of the critical impact on our planet of four global trends:



- **Population growth:** The world's population passed the billion mark in 1800, exceeded 7 billion in 2011, and according to the latest UN predictions, is likely to rise to 9.6 billion by 2050. In future, significantly more hungry mouths will have to be fed and housed in increasingly urbanized surroundings.
- **Urbanization:** In 2008, for the first time in human history, more of the world's population lived in urban than in rural areas. By 2050 over 64% of the developing and 85% of the developed world's population are forecast to be living in urban surroundings.
- **Rising life expectancy:** People all over the world are living longer thanks to improvements in nutrition and healthcare.
- **Climate change:** As the United Nations Secretary General has said, climate change is "the major, overriding environmental issue of our time". The UN Environment Programme warns that "the potential for runaway greenhouse warming is real and has never been more present" because climate change is a "growing crisis with economic, health and safety, food production and security dimensions".

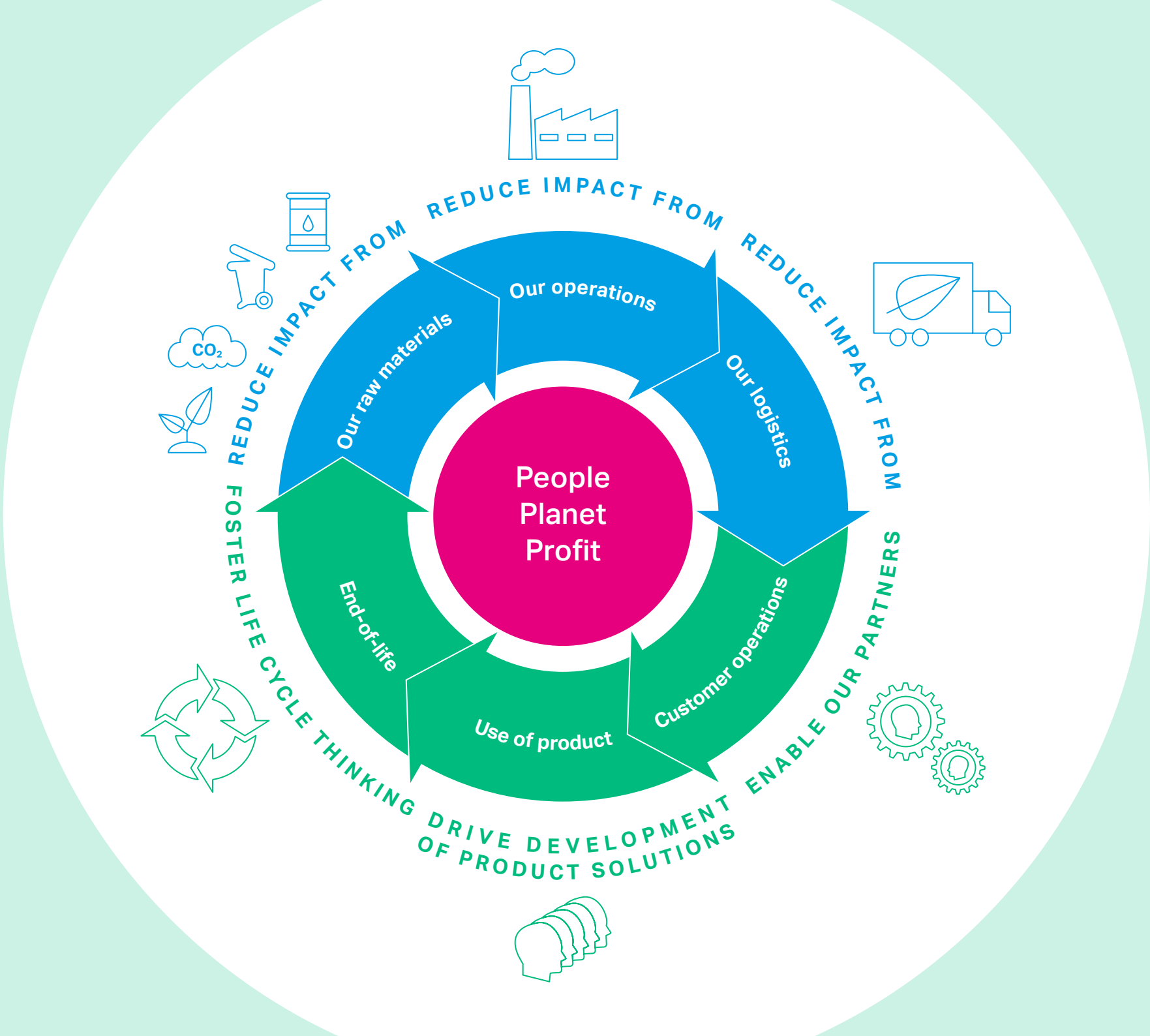


Sustainable development can ease the pressure on our planet's resources while increasing the quality of life and maintaining viable economies. That is why Covestro has placed sustainability at the heart of its strategy and set ambitious sustainability targets for 2025:

- 80 percent of R&D project spending targeted to areas contributing to the United Nations' Sustainability Development Goals (SDGs)
- All suppliers compliant with Covestro's sustainability requirements 50 percent reduction in specific greenhouse gas emissions
- Improving the lives of 10 million people in underserved markets through Covestro's business solutions (e.g. for housing, sanitation and food supplies)
- Getting the most out of carbon for optimal productivity

The "People, Planet, Profit" principle underlines Covestro's understanding of sustainability. These three Ps represent the company's holistic approach to creating social, environmental and economic value while considering the entire product life cycle. Moreover, the three Ps stand for Covestro's efforts to mitigate any negative impact of the company's activities on the environment, move society forward, and at the same time create value. Covestro's sustainability program is focused on the 17 UN SDGs, with climate protection playing a particularly important role.





Polyurethanes – a key contribution to sustainable development

Although polyurethanes are based on oil, a finite resource, they actually help to conserve many resources. For example, when used to insulate a building, polyurethane saves over 70 times more energy during its lifecycle than was needed to manufacture it.





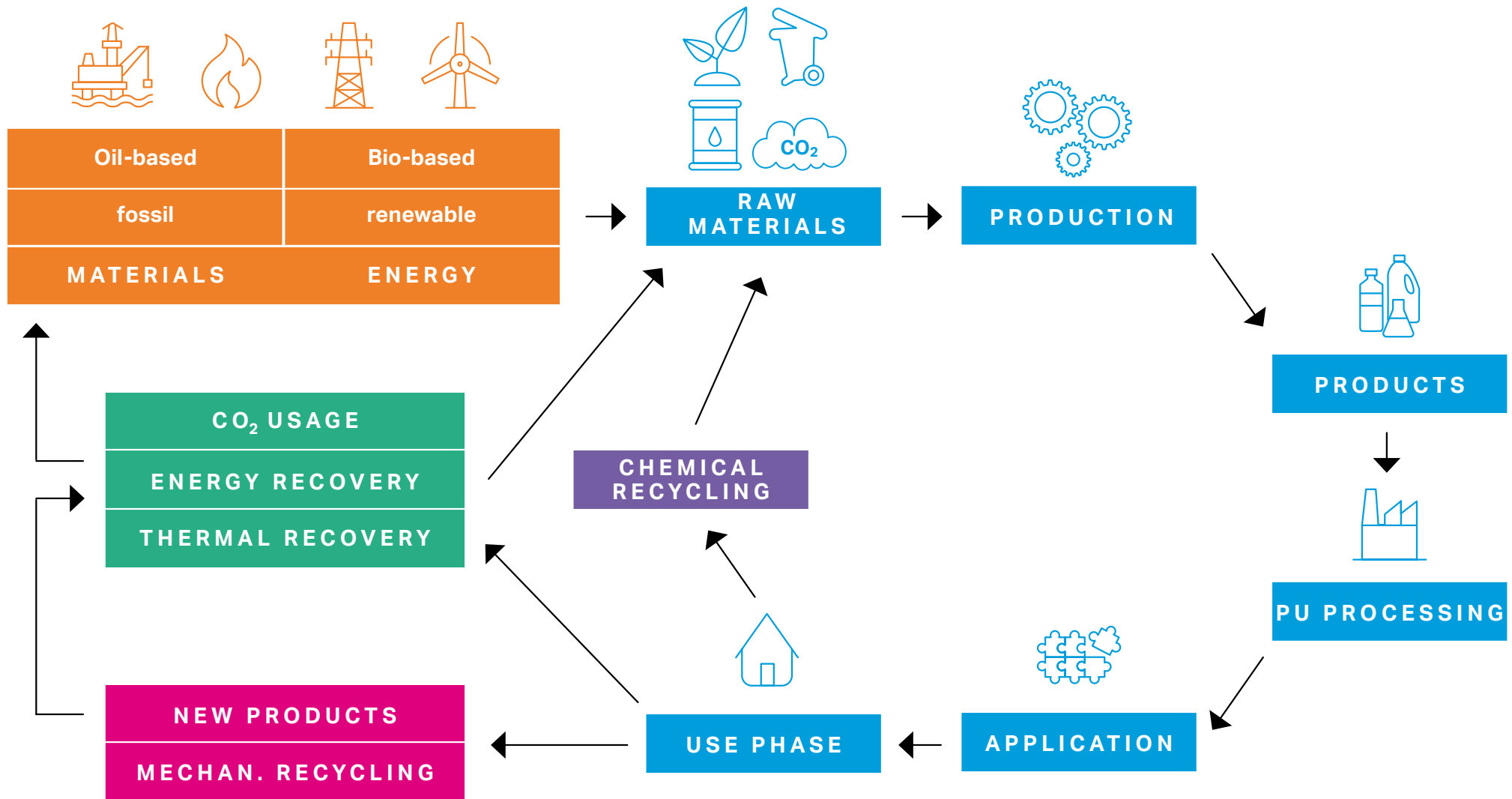
In the EU, approximately 50 million kWh of energy is saved through the use of polyurethane insulation materials alone. At the same time, polyurethanes safeguard or increase standards of living worldwide by bringing greater levels of comfort or convenience to everyday life, for instance through products such as mattresses, outdoor clothing and automotive interiors.

The polyurethane industry is also economically significant, accounting for millions of jobs all over the world.

This brochure looks at the polyurethane industry's contribution to sustainable development in six areas:

- 1 Consumer benefits
- 2 Energy efficiency
- 3 Resource efficiency
- 4 Waste management
- 5 Environmental footprint
- 6 Economic contribution





For us, sustainability means being focused on the entire lifecycle of a product, not just its raw materials.



The polyurethane industry and sustainable development

Despite the fact that the chemical industry is only responsible for around 4% of global energy consumption, whereas transportation accounts for over 14% and buildings for more than 40%, the chemical industry is very much aware that sustainability starts at home and is doing all it can to conserve natural resources for future generations. This is particularly true of the polyurethane industry, which is represented in Europe by ISOPA, the trade association for producers of diisocyanates and polyols, the main building blocks of polyurethanes. For ISOPA, sustainable development means:

- Protecting the environment in everything from resource conservation to biodiversity
- Generating wealth wisely by managing today's resources with future generations in mind
- Promoting social progress through useful, high-quality products

Polyurethanes actively help to fight climate change, for example as effective insulators to improve the energy efficiency of buildings and lower carbon emissions; and in vehicles, where they improve fuel efficiency through being lighter than alternative materials. Moreover, the polyurethane industry is constantly striving to improve the end-of-life phase of its products. Of the 25.8 million tonnes of post-consumer plastic waste generated in EU28, Norway and Switzerland in 2014, 7.7 million tonnes (29.7%) were recycled and recovered. The corresponding figure for energy recovery (i.e. incineration of plastics that cannot be sustainably recycled) was 10.2 million tonnes (39.5%). As a result, only 8 million tonnes (30.8%) were landfilled, 38% less than in 2006*.

* Source: Consultic, quoted in "Plastics – the Facts 2015, An Analysis of European Plastics Production, Demand and Waste Data" published by PlasticsEurope, the Association of Plastics Manufacturers



PEOPLE

How consumers benefit from polyurethanes

Through the durability, versatility and comfort polyurethanes offer they can make a significant contribution to ensuring substantial levels of satisfaction, comfort and safety in many areas of everyday life, as the following examples illustrate.





Polyurethane foams adapt to and support the body. This is why we feel better for longer and experience less fatigue if chairs and beds use polyurethane foams.

Mattresses:

Polyurethane (PU) foam is widely used in mattresses to provide both comfort and support, while the open cellular structure of PU foam permits good ventilation and heat transfer. Cardyon[®], an innovative raw material developed by Covestro for the production of PU foam, is made with up to 20% carbon dioxide, thus replacing some of the crude oil hitherto used to make PU foam. Tests have shown that cardyon[®]- based products are better, or at least as good as, conventional solutions. Moreover, cardyon[®] closes the carbon loop by bringing carbon dioxide, a waste greenhouse gas, back into the value chain.

Furniture:

Polyurethane foam is found in most soft furnishings, where it generates a sense of comfort and relaxation. In office furniture, theatre or conference seating, for example, it is the resilience, durability, strength and comfort of polyurethanes foams that are most important.



Transportation:

Most cars and lorries have polyurethanes in their interior fittings to reduce vibration, and in their seat cushions to ensure comfortable but safe seating. Car bodies contain polyurethanes to reduce noise and heat emissions, while polyurethane bumpers absorb impact in the event of a collision. The use of lightweight polyurethane reduces a vehicle's overall weight and thus increases its fuel efficiency. Polyurethane is also used in trains and planes to make comfortable and safe seats.

Sports and leisure:

The right clothing and equipment are a critical factor at any level of sport and for many leisure activities. Polyurethane-based coatings for sports and functional outdoor clothing ensure the textiles are lightweight, waterproof and breathable. Soles made of polyurethane foam are light and durable as well as providing excellent cushioning, while polyurethane-based adhesives deliver a long-lasting, flexible and eco-friendly bond between sole and upper.

Good footwear should be comfortable, long-lasting, and appropriate for usage. Polyurethanes let designers meet all these goals.





'Polyurethane-based coatings for sports and functional outdoor clothing ensure the textiles are lightweight, waterproof and breathable.'

Polyurethane is also found in sporting equipment. Covestro and adidas have been successfully collaborating to produce polyurethane-based soccer balls since the 1986 World Cup. Other kinds of sports equipment that benefit from lightweight but durable polyurethane include skis, inline skates, kickboards, bike seats and fitness machines.

Polyurethanes bring direct benefits to consumers and improve living standards through their use in insulation, refrigeration, packaging, carpet underlays, coatings and many other everyday applications.



PEOPLE

BAYTHERM® Microcell – an eco-friendly innovation

BAYTHERM® Microcell, an innovative insulating material developed by Covestro, is made up of pores that are not much thicker than a human hair. The size of the pores determines the insulating qualities of foam – the smaller the pores, the better the insulation. Covestro has reduced the size of the pores in conventional rigid polyurethane foam by 40% and thus enabled insulation-related energy savings of up to 6%.

While this innovative micro-foam spectacularly proved its insulating qualities on the first ever round-the-world flight by the solarpower plane Solar Impulse 2, its main application area is in insulating refrigerators and freezers. A major refrigerator manufacturer has already switched its production to BAYTHERM® Microcell and other manufacturers have expressed interest because of the superior insulating qualities of this micro-foam. What's more, Covestro is developing ways of reducing the pore size even further – for an even better insulation and energy efficiency performance.



PEOPLE

Improving the cold chain to create a more sustainable future

As much as 50% of the food produced in developing countries goes to waste because it cannot be stored or transported at a low temperature.



Efficient refrigeration could help feed the rapidly increasing populations of many developing countries. At the other end of a temperature controlled supply chain, inefficient refrigerators and freezers are real climate killers. For example, replacing all old refrigerators with a B or C energy-efficiency rating with A++ ones would reduce the EU's CO₂ emissions by some 22 million tons a year – the equivalent of the entire amount emitted by a country such as Jordan. A++ refrigerators are 60% more energy-efficient than 15-year-old models.

Polyurethane's key role in the cold chain

Polyurethane insulating foam plays a key role throughout the cold chain – from insulating animal sheds and distributing perishable goods in refrigerated containers to storage in cold stores, local storage in supermarkets, and domestic refrigerators, freezers or portable coolers. For years, Covestro has regarded a more efficient and economical cold chain as one of the solutions for sustainable development. Moreover, it has been utilizing polyurethane's properties as a highly efficient insulating material in the on-going development of lightweight and cost-efficient refrigerators and other cold storage elements.


Since polyurethane offers a unique combination of a lightweight and closed cell structure, it has a very favorable insulation-to-thickness ratio, which saves space and material while achieving the required insulation values.

'For years, Covestro has regarded a more efficient and economical cold chain as one of the solutions for sustainable development.'

A sound ecological, social and economic balance

The improvements in the cold chain made possible by polyurethane insulating materials are a perfect example of how progress towards the goal of sustainable development brings threefold benefits: ecological gains through reduced CO₂ emissions; social gains through an improvement in levels of nutrition and health in developing countries; and economic gains through higher living standards and quality of life in both the developing and developed world.



A woman wearing a vibrant yellow sari with large blue and pink floral patterns is seen from the side, her hands busy with a white cloth. She is standing at a market stall. In the foreground, there are several woven baskets filled with fresh produce: a basket of bright red tomatoes, a basket of purple onions, and a large basket of light-colored potatoes. In the background, more baskets of tomatoes are visible. The scene is set outdoors on a dirt ground, capturing a moment of daily life in a market.

Roughly one third of the food produced in the world for human consumption every year – approximately 1.3 billion tonnes – is lost or wasted (source: UNEP).

Future benefits

Polyurethane will continue to make a major contribution to our wellbeing in the future. This is reflected in Covestro's sustainability goal of improving the lives of 10 million people in underserved markets through its business solutions, such as those for housing, sanitation and food supplies.

As the first major European manufacturer to join EP100, a global collaborative initiative of influential businesses that have pledged to double their energy productivity by 2030, Covestro has committed to doubling its energy productivity by that year (from a 2005 baseline). Moreover, Covestro is targeting a 50% reduction in its CO₂ emissions by 2025, of which around 40% will be from enhanced energy efficiency.





High-tech polyurethane insulates refrigerated containers in which below-freezing temperatures may need to be maintained.

Product innovations benefit people in underserved markets

“The proof of the pudding is in the eating”, as the saying goes. In Covestro’s case the proof of its commitment to improving the lives of 10 million people in underserved markets is seen in the solutions it is providing to avoid post-harvest food wastage and improve food security in poor, climatically challenged countries. In Thailand, Vietnam, Myanmar and India (where estimates indicate that 20-50% of total food production is lost post-harvest) 900 dryer domes made of a glass-like polycarbonate with better-than-glass mechanical properties were installed in 2016 to help avoid post-harvest food wastage and boost the earnings of smallholder farmers.

But food security is not the only area where Covestro’s product innovations are making a difference. In India and Malaysia, 177 hygienic toilets based on polyurethane rigid foam (PIR) technology were installed in 2016. Another PIR solution from Covestro is making affordable housing possible in Iraq, Malaysia, the Philippines and India, where 40 units displaying outstanding insulation and mechanical properties were installed in 2016.



PLANET

Protect the planet – we haven't got a spare one

Polyurethanes play a key role in preserving our planet's natural resources. Generally speaking, polyurethanes make improvements in energy efficiency, resource efficiency, waste management and environmental footprints possible. Specifically, Covestro has pioneered a number of projects and products that are making a very targeted contribution to protecting the planet.



Climate change is probably the greatest environmental challenge we face today. Mankind's thirst for fossil fuels for use in transportation and heating or cooling buildings has increased carbon dioxide levels in the atmosphere, which are generally considered to be the prime cause of climate change.

One effective means of radically reducing CO₂ emissions is to improve energy efficiency.

Polyurethanes can contribute to greater energy efficiency by reducing the demand for fossil fuels in buildings, transportation and household appliances. And although polyurethanes are made from oil, their lifetime energy balance is positive.

Highest insulation efficiency and outstanding eco-balance

Buildings are the biggest source of CO₂ emissions, accounting for more than 40% of global energy use and a third of global greenhouse gas emissions, according to figures from the United Nations Environment Program's Sustainable Buildings and Climate Initiative.

Improving the insulation efficiency of buildings is pivotal in combating climate change. Thermally insulating the envelope of a building is a key factor in optimizing a building's energy performance – and rigid polyurethane foam is one of the most efficient thermal insulants, to say nothing of its durability and fire safety qualities. Polyurethane insulates so well because of its low thermal conductivity, as the following figures show:

- An additional 10 cm layer of rigid polyurethane foam (PIR) reduces the energy loss of a typical 1950s wall by more than 70%.
- 1.6 cm of PIR wall insulation has the same insulation efficiency as a 1.34 m thick concrete wall.
- The aging durability of polyurethane means its service life is equivalent to the useful life of an insulated building, e.g. 50 years.
- After 50 years, 99.5 times the energy initially invested to produce the polyurethane will have been saved (calculation based on energy efficiency requirements for buildings in Germany).



Green roofs contribute to environmental, functional and design improvements in the living and working environment (photo: alwitra).



Bio-based aniline

Up to now, aniline, a key feedstock in PIR production, has been derived from benzene, a petroleum-based raw material. Each year, around 5 million mt of aniline are produced worldwide and we are one of the leading producers with a production capacity of around 1 million mt. Now, we have developed an innovative new process to produce aniline from plants, e.g. feed corn, straw or wood. The new process uses a microorganism as a catalyst to convert the industrial sugar derived from such plants into an aniline precursor, from which aniline is then produced by means of chemical catalysis. After successfully producing aniline in a laboratory, we are working with industrial and research partners to upscale the process in a pilot plant and, ultimately, produce bio-based aniline on an industrial scale.

Urban sustainability through collaboration

In North America, we are proactively involved in the 2030 Districts Network, whose goal is to halve energy consumption in existing buildings, water consumption and transportation greenhouse gas emissions and to make new buildings carbon-neutral by 2030. The network's goals align well with our focus on promoting more sustainable building solutions through high-tech materials, such as energy-efficient polyurethane insulation and solvent-free coatings.



The 2030 Districts Network already encompasses 17 urban districts in the United States and Canada, and is growing all the time. As education is seen as key to achieving the sustainability goals of the 2030 Districts Network, it is leveraging its local district chapters to inform property owners, institutional investors, managers, developers and others about how to improve building performance. Through strategic partnerships established with professional and community stakeholders, the 2030 Districts Network is providing all those concerned with the education, services, tools and support they need to accomplish these performance goals.

We have a senior employee on the 2030 Districts Network Board of Governors, and we are also very much involved in the Pittsburgh 2030 District, where the company's North America headquarters is located. Our proactive participation in the 2030 Districts Network at a national and local level reflects the company's focus on developing materials that address the challenges of increasing urbanization, as well as its conviction that urban sustainability can only be achieved through collaboration.



PLANET

Preserving, recycling and recovering resources

Although polyurethane possibly makes the greatest contribution to sustainable development through enhancing energy efficiency, it also brings environmental benefits through improvements in resource efficiency, waste management and environmental footprints.



Boosting resource efficiency

Polyurethane promotes resource efficiency in a number of ways:

- **Prevention and minimization:** Resource efficiency is improved through prolonging the durability of materials, preserving food and conserving biodiversity.
 - **Greater durability:** Durable polyurethane coatings prolong the life of materials, e.g. through improving the corrosion and weather resistance of all kinds of surfaces. The durability and abrasion-, chemical- and oil-resistant properties of polyurethane elastomers are advantageous in a wide range of applications, including conveyor belts, rollerblade or trolley wheels, and automotive components.
 - **Preserving food:** Besides the advantages of a more efficient cold chain, polyurethane is excellent for packaging applications because it cushions and absorbs shocks. And since polyurethane-based packaging adhesives are heat-, cold-, water- and chemical-resistant, they are also very suitable for preserving food.
 - **Conserving biodiversity:** Illegal logging and deforestation are significant issues in many parts of the world. Composite wood products using sustainable forestry resources and polyurethane adhesives are a genuine alternative to panel products made from large mature trees.
- **Re-use:** The high longevity and re-use of polyurethane products also contribute to resource efficiency. Polyurethane-based furniture, textiles or footwear retain their properties over many years and can be used by multiple owners. In the construction industry, for example, metal-faced polyurethane panels can have a second life after dismantling, resizing and re-installation.
- **Recycling:** Waste polyurethane can be efficiently recycled if the material is pure polyurethane and not mixed with other plastics. Moisture cured polyurethane adhesives, for example, can be used as binders for re-milled rubber waste or crumbs in applications such as running tracks or garden tiles. However, end-of-life products are mainly mixtures of various plastics for which a large-scale economically viable and ecologically sound solution has not yet been developed.
- **Recovery and disposal:** Where polyurethane materials cannot be recycled, recovery is a sensible alternative. Tonne for tonne, polyurethane contains as much energy as coal, which makes it a very efficient feedstock, e.g. for municipal incinerators that use the energy generated to heat buildings.



Improving waste management

The end-of-life treatment of products containing large quantities of polyurethane foam is expected to change significantly in the near future. One ecologically favorable change will be that huge quantities of plastic waste will no longer be landfilled but treated in energy recovery facilities (i.e. incinerated). The EU has set its member-states a target of reducing landfill to a maximum of 10% of municipal waste by 2030. Currently, around 30% of post-consumer plastic waste is still being landfilled so it is a challenging target. However, Europe's plastics industry is committed to doing all it can to reduce landfilling and thus achieve this sustainability goal. Recycling plastic waste is always the preferred option, with energy recovery the alternative for plastics that cannot be sustainably recycled.

Working towards a better environmental footprint

Just how sustainable development helps to save the planet through enhancing energy and resource efficiency and improving waste management has been described on the previous pages. What ultimately counts is that the use of polyurethane in all these different ways is working towards a better environmental footprint of the specific products or processes.



Any film or non-woven material is removed from polyurethane rigid-foam waste before it is crushed and pressed into pellets (photo: Linzmeier).



Our Building of the Future in Bottrop city center can serve as a model for the many commercial properties in Germany and elsewhere that have not yet been energetically refurbished. Professionally executed refurbishment and state-of-the-art building technology can help reduce a building's energy consumption by up to 80%.



PROFIT

Only economically profitable development is sustainable

Development is not sustainable unless it is also economically profitable. We know that every kilogram of carbon invested in the company's products should both generate profit and reduce the consumption of carbon elsewhere. However environmentally friendly and socially desirable a product may be, it will not survive unless it is manufactured profitably.



Economic significance of the polyurethane industry

According to Eurostat figures, the European plastics industry employed 1.45 million people and was made up of 62,000 companies (mostly SMEs) that generated a total turnover of over €350 billion in 2014. The industry in the EU had a positive trade balance of €18 billion (from plastics raw material producers and plastics converters) and contributed around €27 billion to public finances. It is interesting to note that the majority of companies in the polyurethane industry are actually small or medium-sized enterprises (SMEs). These figures show that the polyurethane industry is an impressive creator of jobs and revenues that are made possible by producing products that people want and need.

Economic benefits for the consumer

Renovating buildings to make them more energy-efficient has a twin benefit in Europe's current economic climate: first, renovation work safeguards existing jobs or creates new ones; second, it significantly reduces energy wastage and cuts heating

or air-conditioning bills. The durability of polyurethane products is another money-saver. These examples show how businesses and individuals can profit from polyurethane-based products.

Securing sustainable development through innovation

We have a proud record of innovative achievements and have been at the forefront of pioneering advances in applied chemistry. Through innovations in the field of polyurethane technology we are contributing to a sustainable future right now, and investing in the further development of its own process technologies to ensure long-term competitiveness and economic viability. These innovations include the gas-phase technology, a key step in the production of toluene diisocyanate (TDI), which is the basis for polyurethane flexible foams. Depending on the production site, this gas phase technology may well consume 40-60% less energy than conventional technologies.



Reducing our dependence on oil

Although polyurethane brings many benefits, we are well aware that it is an oil-based product. We are therefore working to find ways of partly reducing the dependence on oil through the use of renewable raw materials. The sugar molecules extracted from sugar cane or beet can be used in the production of rigid foam, for example, and renewable raw materials may already account for 5–10% of the raw materials in an insulating panel. Although we are constantly evaluating options to increase the share of renewable raw materials in our product portfolio, any new product developments naturally have to fulfill the strictest product benefit, economic and ecological requirements.

'We now offer a range of cardyon®-branded polyols for use in all kinds of polyurethanes and other coating or adhesive applications.'

The future is now

Crude oil is the traditional raw material of the chemical and plastics industries. As this fossil resource is limited, manufacturers are looking for alternatives. A new source could be CO₂, a field in which we have pioneered a groundbreaking development – a proprietary CO₂ technology that turns a waste greenhouse gas into a valuable feedstock in polyurethane production. On the basis of this technology, Covestro now offers a range of cardyon®-branded polyols for use in all kinds of polyurethanes and other coating or adhesive applications. The use of CO₂ in plastics production benefits the environment by reducing the overall carbon footprint and establishing an alternative carbon source beyond fossil hydrocarbons and bio-based raw materials. In 2016, this innovation was put to industrial use with the commissioning of a 5 kt demo plant in Dormagen. In terms of global CO₂ emissions this is only a small step forward, but for the plastics industry this new source of raw material is both economically and ecologically significant. That is sustainable development in practice.





The European Commission's First Vice-President **Frans Timmermans** on the significance of sustainable development:

'To build a future for our children and our planet to the benefit of everyone we are making the (UN's) Sustainable Development Goals and sustainability a guiding principle in all our work. Implementing the UN 2030 Agenda is a shared commitment and needs everyone's contribution and cooperation, including Member States and civil society at large.'





Promoting a dialog on resource and energy efficiency, Covestro is keen to talk to politicians and concerned individuals throughout the world. After all, polyurethane not only contributes to resource and energy efficiency but also creates jobs and wealth.

According to ISOPA figures, the European polyurethane industry employs more than 817,000 people and generates a market value of over €125 billion.

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