BIOPLASTICS

IT'S A BETTER CHOICE

THE FOSSIL-FREE ALTERNATIVE

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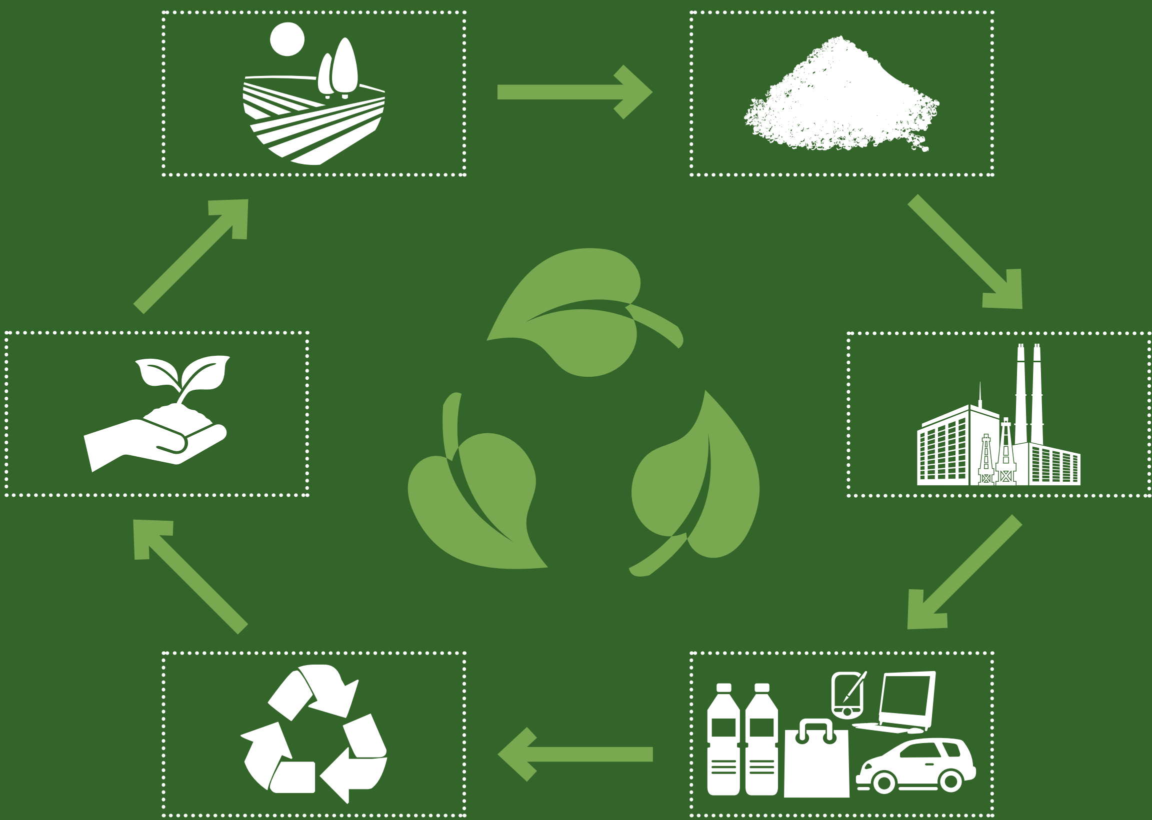

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BIOPLASTIC – A NATURAL MATERIAL FOR A BETTER FUTURE

As Al Gore noted years ago when the climate debate was just gathering steam, no other material evokes such strong reactions and opinions as plastic.

Of course, this still holds true, but the debate has changed over the years. The overarching objective today is the creation of a circular society, with the mantra "reduce, reuse, repair, recycle", and where bioplastics are certain to play a big role.

Biobased plastics are significantly less demanding on the planet's limited natural resources and help contribute to a fossil free society with reduced greenhouse gas emissions.

The long-term vision is the discontinuation of new fossil-based plastic production and that the fossil plastics already in circulation will be phased out circularly over the materials' life cycle, but no one is certain how long this process will take. The only thing we can say for certain is that development is progressing at a rapid pace.

October 2018 saw the launch of the "New Plastics Economy Global Commitment", which unites decision makers in the business community, political world and other organisations on the global level to promote a shared vision for addressing plastic use in the future.

The work was led by the Ellen MacArthur Foundation in collaboration with the UN Environment Programme. More than 350 leading players have lined up behind the commitment to move towards a circular economy, where plastics will continue to play an important role in the society of the future—but will no longer pollute our oceans.

Bioplastics are a very important piece in making this vision a reality, both recyclable and compostable products.

This approach will require the development of greater awareness at the level of the individual citizen and the plastic industry, and among the major global brand owners and political circles.

This publication is intended to be used as basic learning platform.

Bioplastics have been around for a long time

The fact is that plastics produced from renewable raw materials have been around a lot longer than fossil-based plastics.

As early as the 16th century, casein from cheese production was already being used as a filler material in the intarsia (wood inlaying) on finer pieces of furniture.

In 1870, cellulose nitrate started being used in place of ivory to make billiard balls. The new material was given the name, celluloid, and was made by treating cotton, which consists of cellulose fibres, with nitric acid.

Cellophane and bakelite are other examples of early bioplastics that were developed in the early 1900s.

Polyester PLA is a bioplastic that is nearly 100 years old (*1920s*) and is still quite relevant today. The first bioplastics based on soy beans were developed in the 1930s by Henry Ford.

In other words, the first plastic products were actually developed using plant-based materials.

But in the early 1900s, the commercial focus instead shifted to crude oil as a raw material, and the fossil-based era of plastic began. The interest in biobased plastics once again gained

momentum in the1980s, primarily focused on the mass production of corn-based PLA.

In theory, bioplastics can be made using all types of renewable raw materials. The challenge is breaking down the biological material into suitable building blocks, which can then be put together into polymer chains.

Wood fibre, algae, chicken feathers, wastewater, vegetable waste, fry oil—the list of potential raw material candidates can get quite long.

Why plastic?

When we look at the big picture, plastic products that are included in the circular economy provide a tremendous environmental benefit—even fossil-based plastic products. When plastics are produced with renewable raw materials, the environmental benefit is even greater thanks to the low carbon footprint.

However, it is important to calculate this into the life-cycle analysis correctly and consider all possible aspects. One example is the recent history of the single-use plastic grocery bag, which has made a comeback from being essentially banned to suddenly being named the most environmentally sound option—even if the bags are fossil-based. And as for the organic cotton grocery bag that is sold as the eco-friendly option in nearly every shop in the country—it would have to be used 20,000 times to have the same environmental and climate impact of a single-use plastic bag. *

In comparison to many other materials, plastics are considerably lighter, which offers a number of advantages, including significantly lower fuel consumption during transport.

Plastic can be moulded at relatively low temperatures - a few hundred degrees - compared to over a thousand degrees for glass and metal.

Plastic provides many more design options and enables the integration of a wide variety of functions. These characteristics allow complex products to be manufactured in designs that cannot be executed in other materials without costly and time-consuming retrofitting.

Tomorrow's bioplastics will be applied for uses we can only imagine today.

But what are the down sides?
One monumental problem is that a certain amount of plastic finds its way out of the circular system, resulting in serious consequences, such as the islands of plastic in our oceans and microplastics in our environment. This is a big environmental challenge that requires our immediate attention and decisive action.

It is important to remember that the march towards a sustainable society is moving steadily forward, even if we don't notice the transformation in our daily lives. Tremendous resources are being invested in research and development, while efforts are in full swing to create regulatory frameworks for technical, economic, political and social aspects of the different industrial strategies employed to realise the vision of a sustainable society as quickly as possible.

** "Life Cycle Assessment of grocery carrier bags", DTU Environment on behalf of the Danish Environmental Protection Agency, 2018*

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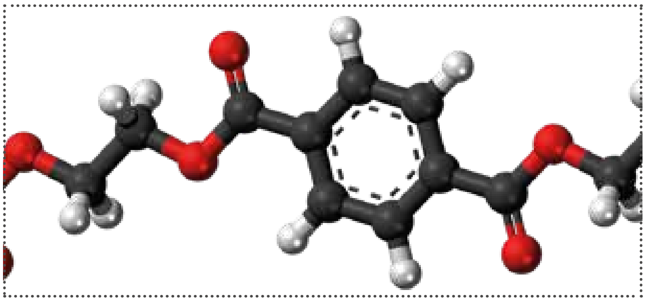
A CRASH COURSE IN MATERIAL KNOWLEDGE

There is often a bit of a misconception when one hears the term, bioplastic. Therefore, it seems only appropriate to sort out some key terminology before going any further.

In order to understand the difference between bio-based plastics and fossil-based plastics, we first need to define the central term—plastic. So we will start out with a little chemistry lesson.

A plastic is a substance consisting of long polymer chains with different additives blended in to create the desired characteristics. A polymer chain can be thought of as a pearl necklace containing a long series of pearls.



These long polymer chains consist of a series of smaller, repeated units (*monomers*), which can be likened to small building blocks that are chemically hooked together.

It is the monomer structure that determines what kind of plastic is produced. The simplest structure is formed from polyethylene, which forms carbon dioxide and water upon combustion.

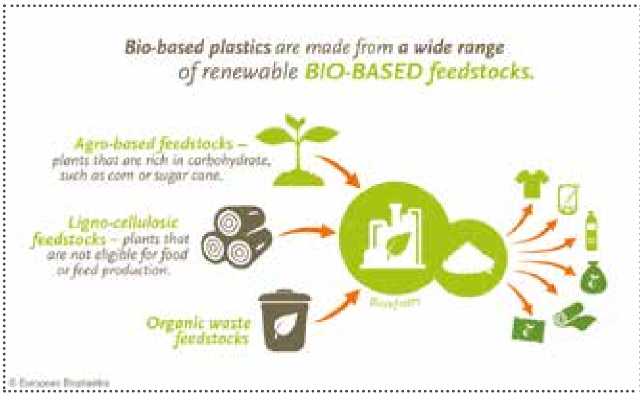
Polymers can be divided into groups of natural and synthetic polymers. The natural polymers occur naturally in the environment and include different types of sugars/starches, proteins and lignins. Synthetic polymers are artificial, man-made products mainly produced from petroleum oil.

Plastics can be further divided into thermoplastics and thermosets. Thermoplastics can be remoulded several times with the application of heat, which is not possible with thermosets.

Both of the above plastic types are available as bioplastics, however, biobased thermoplastics are the most prevalent. These are the plastics we will focus on here.

There are other concepts and abbreviations used in the plastics industry that you will come across further along in the course; we have included a glossary at the end of the book for your reference.

Bioplastics produced from renewable resources



Biomass from agriculture and the forest industry and food waste are some of the raw material sources for bioplastic.

Biomass is organic material that can consist of anything from energy crops to residual products and agricultural and forest industry waste. Biomass has a variety of useful applications, including the production of biofuels and bioplastics.

The biomass used in bioplastic production currently comes mainly from maize, sugar cane and cellulose.

In total, about 172 billion tonnes of biomass is generated each year, while only about 3.5 percent of this is used, mostly for food and livestock feed.

The real challenge is transforming the raw material into suitable building blocks to build the polymer chains. This can be done through a biochemical process, e.g., through fermentation using enzymes or microorganisms, or through thermochemical gasification of the biomass material.

First generation raw materials for bioplastic include carbohydrate-rich plants such as sugar cane, sugar beets, maize and other agricultural products. The advantage offered by fast-growing crops, such as sugar cane, is that these crops bind large amounts of carbon in a short period of time and the yield far exceeds the yield generated by a Nordic forest, for example.

Second generation raw materials include cellulose and inedible byproducts from the food industry and feed crops, such as vegetable oils. These residual substances are typically left to break down on the ground, thus maintaining the soil's carbon reserve. This process results in a carbon surplus, which can be managed in bioplastics production.

Third generation raw materials are still largely in the experimental stage of development and have the potential to open the door to a new world of opportunities. These materials include algae, carbon dioxide and methane, where competitive bioplastic production methods are a direct carbon trap for greenhouse gases.

Today, first generation raw materials are largely used for bioplastic production. There is currently aggressive research underway for the subsequent generations of raw materials, where a major challenge is the development of efficient production techniques.

Carbon footprint

As a plant grows, it takes in carbon dioxide from the atmosphere. When a plant is consumed (*through decomposition, incineration*), carbon dioxide is released and returns to the atmosphere. If everything is in balance, this is a carbon neutral cycle.

Crude oil, on the other hand, has been holding its carbon for millions of years, and when this is released, the total atmospheric carbon dioxide level is raised to such a degree that the earth's vegetation cannot maintain this balance.

The term *Carbon Footprint, CFP*, is a standardised term used to quantify a product's total greenhouse gas (*GHG*) emissions. In order to simplify the calculation, this is often expressed in terms of the total carbon dioxide emitted, or the total equivalent emissions of other greenhouse gases.

The method for measuring a product's carbon footprint is described in greater detail in ISO standard 14067.

Bioplastics made from renewable raw materials offer a unique advantage over fossil-based plastics in this regard in that they not only reduce the use of finite fossil resources, they also help reduce emissions of the greenhouse gas, carbon dioxide, which increases global warming.

Living organisms take in carbon dioxide from the atmosphere, which is then stored in plastic made from renewable biomass. This captured (sequestered) carbon stays with the material during all stages of the product's life cycle and during recycling up until the time of incineration.

If we could replace the entire global annual production of fossil-based polyethylene (*PE*) with biobased PE, we would reduce the carbon footprint of the material by 500 million tonnes. *

This corresponds to the carbon dioxide emissions from 300 - 500 million mid-sized cars, depending on the driving distance and fuel consumption.

**LCA study, Braskem/ACV Brazil, 2018*

Life-cycle analysis

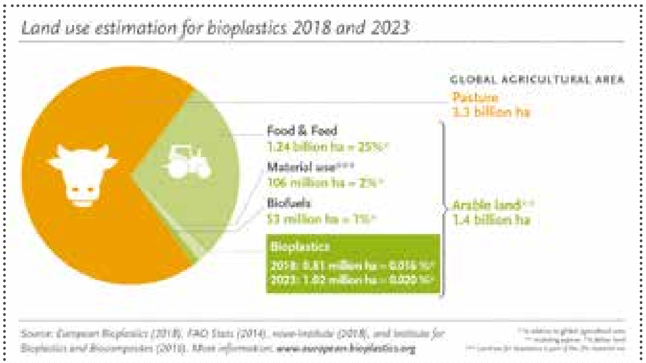
One effective way to measure the environmental impact of a material is the life-cycle analysis (*LCA*). Life-cycle analysis is a product specific assessment that encompasses the product's environmental load through the entire chain. LCA involves the assessment of the environmental impact with regard to materials, manufacturing, transport, recycling, etc.

By applying a life-cycle analysis, a product's carbon footprint can be expressed as carbon dioxide

equivalents. A product's total carbon dioxide emissions are documented in accordance with the standards ISO 14040 and ISO 14044.

Bioplastic reduces the carbon footprint – every tonne of bio-polyethylene that replaces fossil-based polyethylene reduces the carbon footprint by five tonnes.

Farmland for plastic production?



In 2018, the global production capacity for bioplastic was 2.11 million tonnes, which corresponds to less than .02 per cent of the world's agricultural land.

Assuming growth in bioplastics continues at the current pace, this number will be exactly .02 per cent in five years (*2023*). This does not include food waste, non-food crops or cellulosic biomass—only the production related to the use of agricultural land. And the use of these raw materials actually alleviates the demand for increased agricultural area.

If we look at the global trends in capacity, Asia is a major production hub, with over 50 per cent of the world's total bioplastics production. Europe currently accounts for one-fifth of production resources, but that share is expected to grow to 27 per cent by 2023, largely due to initiatives within a number of European countries.

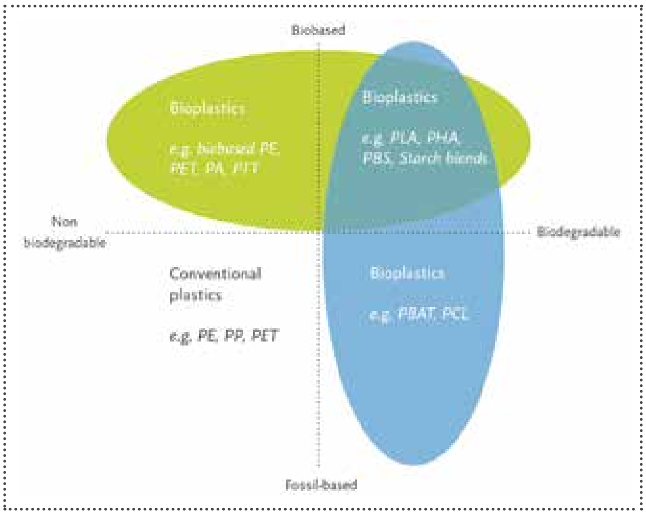
Sustainable products require a sustainable flow of raw materials from biomass, therefore, a number of initiatives have been undertaken to ensure the establishment of sustainable targets. Examples include the Better Sugar Cane initiative and the independent certification of sustainability criteria to ensure compliance with the European Renewable Energy Directive (*RED*).

Bioplastics are not necessarily biodegradable

A common misconception is that bioplastics are always compostable and that it is not a major concern if the material ends up in the natural environment, since it will simply break down quickly into its constituents.

It is not quite that simple. Just because plastic is made from renewable raw materials does not always mean it is a biodegradable product that breaks down through the action of microorganisms. Likewise, not all biodegradable products break down quickly enough to meet the criteria for compostability. The terms used here are defined in more detail on page 17.

Therefore, the term biobased does not always mean a product is biodegradable/compostable. There are bioplastics on the market that are made from renewable materials that break down the same way as fossil-based plastics:



The figure shows the difference between different fossil-based plastics and bio-based plastics and where they fall in terms of the degradation process.

Today, non-biodegradable bioplastics account for 56.8 per cent of the global bioplastic production capacity.

Identical structure or variant?

To further complicate matters, there are even more important concepts to acquaint yourself with:

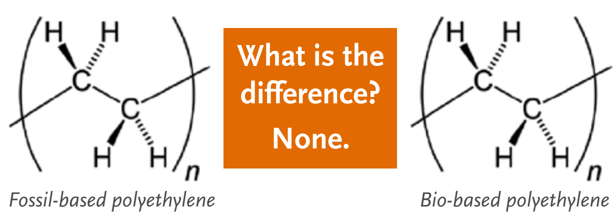
"Drop-in" - means that the plastic is wholly or partially made with renewable raw materials and has the exact same chemical structure as its fossil-based counterpart. This indicates that the bioplastics are not biodegradable, yet they do have a bio content that contributes to a reduced carbon footprint.

For example, bio-based PE, PP, PET and PA are not biodegradable and do not meet the requirements for compostability under European standard EN 13432.

These bioplastics have the same properties as their fossil-based counterparts and can be processed in the same manner as conventional fossil-based plastics.

An additional advantage is that they can easily be co-mingled and recycled with conventional fossil-based plastics.

At just over 25 percent of the total bioplastics market, the largest bioplastic in this segment by volume is PET. Bio-PP and PEF are still in the development stage, though they are expected to be available on a commercial scale by 2023.



Biobased within a known family – these have their own structural variations within the framework of their family, which creates characteristics that can differ from their fossil-based family members. Examples include the polyesters PLA and PHA and the polyamide PA11. These bioplastics are also wholly or partially produced using renewable raw materials.

Fully or partially biobased

PLA, PHA and bio-PE are examples of bioplastics that are up to 100 per cent bio-based.

Based on the accepted definition of a bioplastic, a material can have a lower proportion of bio-based content and still be referred to as a bioplastic. For example, bio-PET can have a biological origin of 30 per cent and 70 per cent fossil content.

Image: Tomra

In other words, mixtures can be a smart environmental choice. A prime example of this is a mixture of 100 per cent bio-based PLA with fossil-based PBAT, which results in a biodegradable product, since PBAT is also biodegradable even though it is a petroleum-based material.

It is common practice for a raw material producer to start with a lower bio content and then gradually increase the proportion. A producer may do this for a number of reasons, including purely process-technical reasons or due to cost concerns pending the scale up of production volumes.

The bio content in bioplastics can be indicated in part by specifying the bio-based carbon content and in part by specifying the biomass content in a product. There are two different measurement methods, and these do not provide comparable results.

A well-established method for measuring a product or material's bio-based carbon content is the C14 (Radiocarbon dating) method (*EU standard CEN/TS 16137 which corresponds to US standard ASTM 6866*). Certification processes and product labelling are used for both European and US standards.

Additives

Polymers are amazing substances, but to create plastics with the right properties, additives are needed. The challenge is selecting the right additives and ensuring these are environmentally friendly.

In order to strengthen the environmental profile of a bioplastic, it is important to use additives that create a low carbon footprint.

In order to prevent the sun from prematurely decomposing a plastic product, UV stabilisers are needed, especially in outdoor products. Pigments may be needed to make the plastic product attractive to users and impact resistance additives may be needed if the product will be subject to tough conditions, i.e., cold weather, rough treatment, etc.

The wonderful thing about plastic is that the properties can easily be customised using a variety of additives. Of course, additives are used in many cases simply to lower the price of the material.

Additives used in biopolymers can be divided into three categories: traditional additives used in fossil-based plastics, additives based on renewable raw materials and biodegradable additives based on renewable raw materials. When considering bioplastics, it is extremely important to maintain control over the additives used so that these materials, to the furthest extent possible, are based on renewable raw materials and that the degradation products are not harmful to the environment. Intensive research is currently underway in this area.

Biocomposites

Additives can also strengthen a material's environmental profile. A biocomposite is a material consisting of a plastic matrix and a bio-based additive that provides reinforcement *(e.g., cotton, linen, hemp)* or wood-based fibres *(cellulose, lignin)*.

The replacement of a significant proportion of fossil plastic with a renewable resource creates an important environmental benefit. Of course, if a plastic is used that is completely or partially made from renewable raw materials, the environmental benefit is even greater.

Biocomposites are low density materials with a lower weight than other alternatives, such as fibre-reinforced plastics. They are also often stronger and stiffer.

This has led to a strong interest in biocomposites in the automotive and aerospace industries, along with other industries.

But it should also be noted that the options for material recycling decrease with an increase in the proportion of fibre additives, since the recycling process strives for material flows that are as pure as possible before the next product life cycle.

Additives and modifiers are typically used in biopolymers to improve:

- barrier properties
- Impact resistance
- Scratch resistance
- Plasticizers(*soybean oil, citric acid base, etc.*)
- Foaming agents for cellular plastic
- Filler materials (*chalk, lime, wood fibre*)
- Colour pigments
- Antioxidants
- UV stabilisers
- Heat stabilisers
- Antistatic agents
- Flame retardants

Degradation of plastics

All plastics degrade over time, even fossil-based plastics. This mainly involves different degradation mechanisms and, above all, differing periods of time that are dependent upon the prevailing environmental conditions.

The plastic breaks down and decomposes into smaller and smaller pieces. The particle size ultimately scales down to the microplastic level, i.e. from five millimetres down to one nanometre (*millionth of a millimetre*). Biodegradable plastic passes through this process and continues to break down into its natural constituents within a reasonable period of time. Non-biodegradable plastics take much, much longer to go through this process.

There can be a big difference in the length of the degradation process for biodegradable plastics. The degree of biodegradability is not necessarily dependent on the raw material that is used, it is dictated by the chemical structure of the biopolymer. The plastics that degrade the fastest are the compostable plastics.

Heat also breaks down polymer chains, which is something that happens, e.g., every time material is heated to make new products. Therefore, a mixture of new material and recycled plastics is often used to provide the desired quality of plastic with stable properties.

The way in which the different bioplastics break down can be summarised by the three main possibilities:

Non-biodegradable bioplastics - degrades exactly the same as fossil-based plastics through heat, UV light, hot water, oxygen and solvents. PE, PP, PET, and PA fall into this group and are highly suitable for mechanical recycling, which is the most commonly used method today.

Biodegradable plastics - degraded by micro-organisms, with or without the presence of oxygen. Moisture and heat are contributing factors. This is full degradation resulting in the end products water, carbon dioxide and/or methane, and biomass. There are fossil-based plastics that are biodegradable, PBAT, for example.

Compostable plastic - for a biodegradable plastic to be classified as compostable, degradation must occur within a specified timefame as defined in European standard EN 13432. Oxygen is needed in this process for the microorganisms to be able to act quickly, as is a suitable balance of moisture and heat. Compostability has a lot to do with the product dimensions, whereby the product's thickness affects the rate of degradation. Therefore, thin products break down more quickly than products with greater material thickness.

Certified compostability

It is almost impossible for an end consumer to easily determine whether a product is made with bioplastic or conventional fossil-based plastic. And making the distinction between biodegradable plastic and compostable plastic is equally challenging. To this end, standards, certifications and marking symbols have been established.

Certain European standards are known as harmonized standards, which means that the European Commission has instructed the European Committee for Standardization (*CEN*) to specify the content of the standard. Certification under such a standard is performed by independent, third-party laboratories.

There are currently a number of different certification systems for industrially compostable plastics. They apply similar testing methods and criteria, but use different certification marks.

Certification is indicated by certification marks, which provides the end consumer with a guarantee that the product is industrially compostable.

It is not only the bioplastics themselves that undergo testing, product-related features are also tested, such as the paint, label, adhesives used in packaging, for example.

The Seedling symbol in the middle of the mark is a registered trademark of European Bioplastics, which indicates that a product or raw material meets the requirements under the standard EN 13432/EN for industrial compostability, in accordance with independent certification bodies, such as DIN Certco and TüV Austria (*Vincotte*).

For example, Standard EN 13432 stipulates that compostability means that at least 90 percent of the plastic is able to be converted to carbon dioxide within six months, and that after three months of composting, no more than ten per cent of remaining plastic fragments may be larger than two millimetres. Testing takes place in industrial composting plants under optimal process conditions in terms of moisture, temperature and the presence of oxygen.

Even if bioplastics meet the requirements for industrial composting, degradation in nature can still take considerably longer than the half-year period in the standard, since our natural environment does not always offer optimal conditions to support the degradation process.

Oxo-degradation

Products that are claimed to be oxo-biodegradable do not fulfil the requirements in Standard EN 13432 for industrial compostability. According to currently applied definitions, oxo-fragmentation is not the same thing as biodegradation.

Oxo-degradable plastic is therefore not considered to be a bioplastic but a fossil plastic with an additive that fragments the plastic or product into smaller particles that remain in the environment for a long period of time.

MANY DIFFERENT TYPES OF BIOPLASTICS

Researchers are constantly testing new raw materials. Wastes, residual products and new bacteria are being used to create new polymers. Many of these advances are still in the experimental stage, others are being scaled up in the production process.

Today, research is underway that is looking at the production of bioplastics using third generation raw materials. The current focus is raw material sources that include carbon dioxide, lignin and algae.

Of course, there is a high degree of interest in the carbon dioxide in the air around us, as this process would provide a fast-acting and very effective way to capture and sequester carbon.

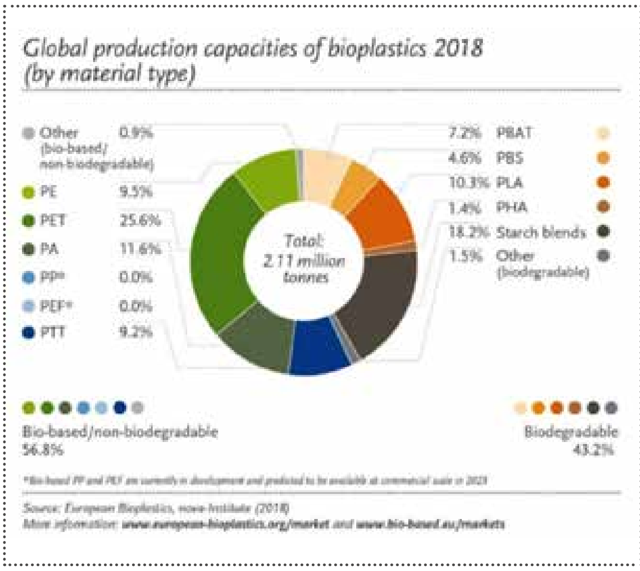
The German company Covestro was the first to use carbon dioxide as a raw material in polyol for the production of PUR.

Here, we will take a closer look at the largest commercial plastic families in the bioplastics industry, and for the sake of simplifying things, we will stick to the classifications, biodegradable and non-biodegradable *(see the definitions in the previous chapter)*.

The volumes for the two groups are currently about the same, but future regulatory action may affect this distribution.

One strategic motivation that could play a role is the desire to simplify the handling of soiled packaging so that it can be composted directly. However, this requires that the disposal method is adapted for high volume industrial composting and that the brand owners are on board.

One very interesting area that is currently under development is biobased structural plastics (*such as PA, PET, PEF*). Structural plastics have more desirable properties than commodity plastics, but at a much higher price. Areas of application include the automotive industry and medical device industry. For example, castor oil-based polyamides are well established on the market today.



The diagram shows the global production capacity of the most common bioplastics in 2018 and a breakdown between biodegradable bioplastics and non-biodegradable plastics.

Biobased plastics are created by

- using naturally-occurring biopolymers (*starch, cellulose*)
- manufacturing bio-based monomers through fermentation (*PLA*)
- manufacturing bio-based monomers directly in microorganisms or genetically modified organisms (*PHA*)
- using bioethanol or biomethanol as a raw material in the manufacture of bioplastics with the same structure as fossil-based (*bio-PE*)

Before we move on to the different types of bioplastics, we should look at the natural polymers once more. In the bioplastics industry, these polymers can be polysaccharides (*carbohydrates*), proteins and lignin. Natural rubber is also a natural polymer that is a great candidate for vulcanization due to its elasticity.

Glucose, fructose and galactose are some examples of monomers in polysaccharides. Polysaccharides occur in animals and plants. Starch is a polysaccharide found in plants in the form of carbohydrate stores.

Proteins are biopolymers built from amino acids, which are the most important "building blocks" in plants and animals. Some common examples of protein-based bioplastics are gluten, casein and collagen.

Lignin (*woody substance*) is found in the cell walls of plant cells and its job is to bind plant tissues and plant parts, making the plant better able to withstand frost, drought and friction. Along with cellulose, lignin is the most commonly occurring organic substance on Earth.

Cellulose plastics were one of the first bioplastics. It is available as regenerated cellulose, better known as viscose, rayon and art silk. From the regenerated cellulose, fibres are spun for textile manufacturing and the thin cellulose film goes by the name cellophane. Cellulose derivatives are available as both esters and ether-based, where the ester derivative is also given the designation, celluloid.

Vegetable oils are also suitable raw materials for making bioplastics. Some examples are soybean oil, rapeseed oil, castor oil and palm oil.

Bioplastics that degrade conventionally

We will start with bioplastics that are not biodegradable. These degrade in the same way as conventional fossil-based plastics when exposed to sun and heat, and some through exposure to water and oxygen or a number of different chemicals. The degradation process does not involve microorganisms.

PE

Bio-based PE consists of up to 100 per cent renewable raw material and is mainly produced from bioethanol extracted from sugar cane. However, it is technically possible to use other raw material bases, which is something that is being thoroughly investigated by researchers across the globe.

The use of bio-PE is expected to increase in the future and new production plants are currently under construction.

Bio-PP

The production of bio-PP on a commercial scale has been a long time coming, but larger volumes of the material are expected to be available by 2023. Bio-based PP is of interest to many industries, not only for applications in the packaging industry but also in technical moulding. Therefore, PP production is expected to increase rapidly in the near future.

Bio-PP raw materials may be bioethanol or renewable hydrocarbons from fry oil, for example.

Bio-PET

PET is manufactured using approximately 30 per cent monoethylene glycol (*MEG*) by weight and approximately 70 per cent terephthalic acid (*PTA*) by weight. In order to be classified as a bioplastic, bio-MEG based on sugar cane is required, since bio-PTA has proven to be far too costly. Research is actively underway to investigate more process steps in order to find an economically sustainable way to increase bio content.

PEF
Belongs to the polyester family and is a 100 per cent biobased alternative to PET.
PEF has excellent barrier and thermal properties, which makes the material a suitable replacement for PET as a bottle material.

Bio-PTT
A member of the polyester family; partially bio-based, exactly like bio-PET. The material makes an excellent fibre for textile manufacturing and in technical products. With requirements for a high surface gloss.

Bio-PA
Bio-based polyamide is made from castor oil; there are several bio-based variants within the family. PA410, PA610, PA1010, PA1012 and PA11 can be produced completely or partially from castor oil. Each variety has its own spectrum of characteristics.
India is the world's largest producer of castor oil, accounting for 80 per cent of all castor oil produced worldwide.

Biodegradability/compostability of renewable raw materials

Biodegradability is a characteristic where microorganisms can break down the material into its constituents: carbon dioxide, water and biomass. Compostability means that biodegradation occurs quickly enough for the material to meet the applicable standard.

Some of the biodegradable plastics include:

PLA
Polylactide (*or polylactic acid*) is usually manufactured through the bacterial fermentation of sugars in corn starch or sugar cane. This bioplastic belongs to the polyester family and is biodegradable/compostable, with a degradation rate that is strongly dependent on the material's degree of crystallinity.

PLA is a highly versatile material and can also be formulated with high-performance qualities that allow it to replace polystyrene, polypropylene and ABS in more intensive applications. It can be foamed and used to replace EPS.
The production capacity is expected to increase by 60 per cent by 2023.

Advantages of PLA
+ Good resistance to grease/oils
+ Good UV stability
+ Compostable
+ Easy to glue
+ Many qualities approved for food grade use
+ High stiffness
+ Transparent

Disadvantages of PLA
- Comparatively high price
- Poor resistance to acids and bases
- Poor impact resistance
- Sensitive to moisture
- Sensitive to cleaning agents

Starch-based plastics

Corn starch is the most common bio-based raw material in starch-based plastics. Starch itself is water-absorbent, which is problematic if you are hoping to create a material with water-repellent properties. However, a variety of modifications have solved this problem.

Bioplastics are currently produced with high starch content, with the remaining constituents primarily being biodegradable synthetic polymers such as PBAT or the polyester, polycaprolactone.

This improves processability and enhances moisture resistance.

PHA

PHA has moved out of the development phase and is now available on a commercial scale, with production volumes estimated to quadruple over the next five years.

These polyesters are up to 100 per cent bio-based, biodegradable/compostable and have a broad range of excellent physical and mechanical properties

PHA is created through the microbial *fermentation* of carbon-based raw material. During the process, the bacteria actually produces the PHA from, e.g., the organic material in a pulp mill's process water. PHA also degrades in the marine environment, which means, in practice, that it can in function as a non-toxic food for fish or bacteria.

PBS

Another biodegradable polyester, usually consisting of partially renewable raw materials. PBS is manufactured from materials including succinic acid and has polyethylene-like characteristics.

PBAT

Something of an anomaly. PBAT is a 100 per cent fossil-based bioplastic, but is completely biodegradable.

Other bioplastics

Bio-PUR: When manufacturing bio-based polyurethanes, a polyol made from renewable raw materials is used. These polyols can be made from vegetable oils, e.g., rapeseed oil, castor oil or soybean oil. PUR was the first material to include carbon dioxide as a raw material base.

Strong, flexible shoe soles made with thermoplastic polyurethane (TPU).

BPA-free bio-PC: There is now a biobased polycarbonate available that does not use the hormone disruptor bisphenol A as a monomer. The material is highly transparent and scratch resistant and has excellent optical and mechanical properties, much the same as the equivalent fossil-based materials.

Liquid wood: The sugars and lignins in wood-based biomass can be used as building blocks for bioplastics.

Liquid wood is one example, which has the appearance of a plastic and acts much the same as a plastic. The material is also biodegradable. The material consists of lignin, hemp or linen as well as wax.

Keratin and Casein Plastic: Chicken feathers, hair and wool contain keratin. Keratin is a strong, stable protein. By using keratin from chicken feathers as a source, a residual product from the food industry can be utilised to make a biodegradable plastic that is more durable than plastics made from soy, starch or other agricultural products.

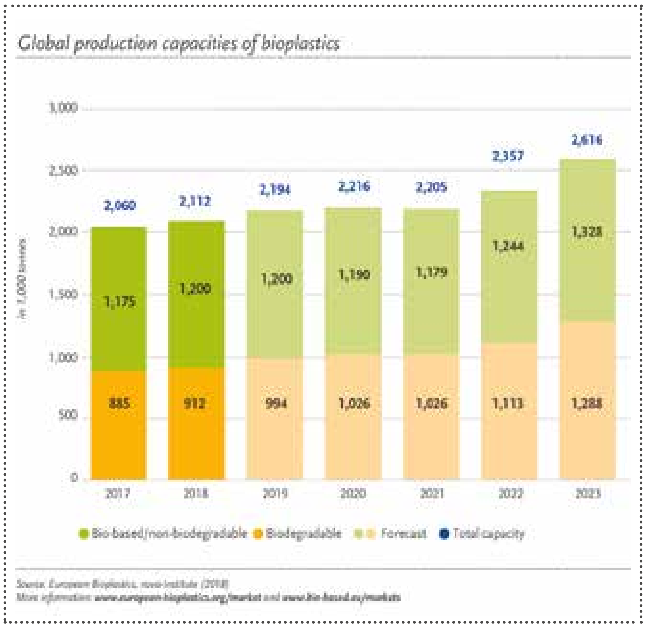
Research has shown that the most important protein in milk, casein, can be used to create biodegradable plastics that can be used for insulation, furniture, packaging and other products. By using casein as a raw material, a degradable material that is hard and brittle is formed.

Plastics based on fungus and algae: Research is also underway to investigate the potential use of mycelia in fungi for compostable packaging. Another suitable material is cyanobacteria, i.e. blue-green algae. ●

PRODUCTION VOLUMES AND AREAS OF USE

Of the 335 million tonnes of plastic produced worldwide, bioplastics accounted for 2.11 million tonnes in 2018.

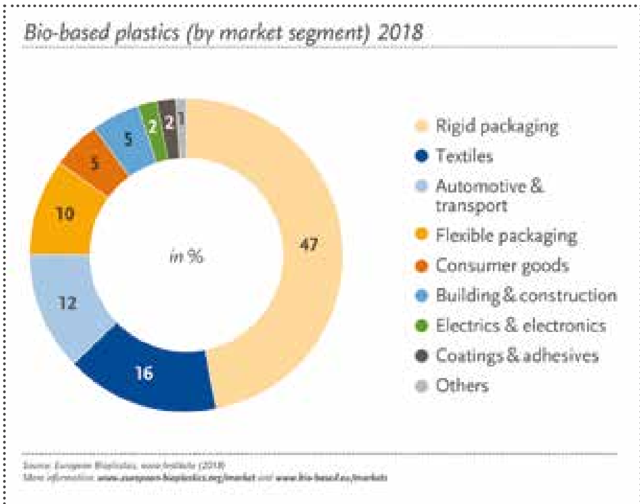
Bioplastic production is expected to increase by 2.62 million tonnes over the next five years (2023), which corresponds to a highly respectable 23.9 per cent increase. This increase may be achieved even sooner if the expansion of production resources occurs more quickly than expected.



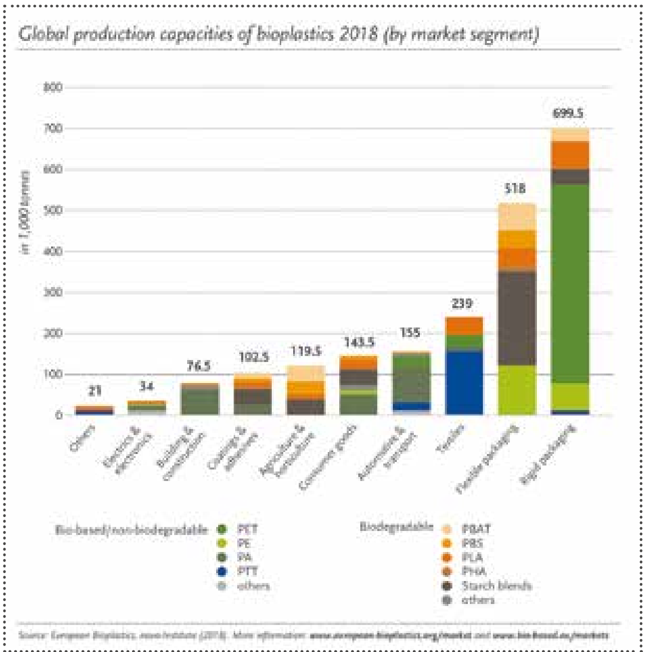
Bioplastics are being used in more and more markets, as the development of high-performance structural plastics progresses.

Bioplastic packaging has been the biggest application area for bioplastics for many years, an area with high production volumes where an important focus is the product's environmental impact. Stiff and soft packaging is still the single largest market for bioplastics at 57 percent (2018).

Other large markets for bioplastics are the textile and automotive industries. Biobased structural plastics are gaining greater and greater interest in applications with higher demands on mechanical, chemical and thermal properties.



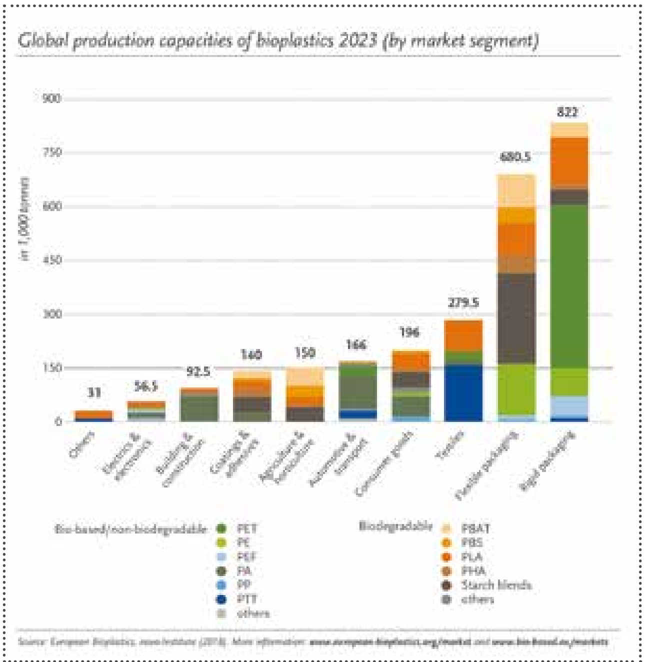
If we break down the different market segments, we can see that the stiff packaging segment is clearly dominated by bio-PET, while starch-based plastics dominate the flexible packaging segment.



Five years from now (2023), packaging will continue to dominate at an increase of 23 per cent. By that time, PEF bioplastics will likely be available on a commercial scale in a composition that is entirely based on renewable raw materials. PEF is expected to give PET some competition for its dominant status, especially considering its superior properties.

If we look at the markets beyond the packaging market, we see that bioplastic use is projected to increase by 18 per cent in the textile industry. PLA's share is expected to see strong growth.

In the automotive sector, growth is expected to be more moderate, largely due to the longer development processes for new vehicle models. On the other hand, things move a lot more quickly in the consumer product market, and bioplastics are expected to increase in market share by a highly respectable 36 per cent over the next five years.



Pricing is very competitive

When a product developer, design engineer or designer develops a new plastic product, the

Image: Freepik.com

choice of material is dictated by the properties that are sought after in the new product—the mechanical properties, heat resistance, chemical resistance, electrical properties, etc.

The material choice is made based on these specifications, while the price profile for the plastic material, of course, has a significant effect. It is often the case that one places too much focus on the plastic's per kilo price, without considering that a more expensive plastic may very well yield a less expensive end product due to greater efficiency in the production stage.

It tends to hold true that bioplastics are more costly than their conventional plastic counterparts, but the price difference has come down over the years as production volumes have increased. To provide a general idea, the price for PLA is about 30 SEK/kg

And at the same time, the number of actors in the sector and the range of different bioplastic qualities are increasing. Most of the actors producing fossil-based plastics also offer bioplastics, and there are now raw material producers that focus exclusively on bioplastics. What all these actors have in common is that they offer tremendous expertise in the sector, which can simplify and accelerate the product development process.

Material selection during development

Plastic provides many more design options and enables the integration of a wide variety of functions, even during the product development phase. These characteristics allow complex products to be manufactured in designs that cannot be executed in other materials without costly and time-consuming retrofitting.

In comparison to many other materials, plastics are considerably lighter, which offers a number of advantages, including significantly lower fuel consumption during transport. Considering its lower weight, technically sound plastic structure and correct material choice, plastic is a material that can be a suitable replacement for metal in the future.

Material databases such as ***www.campusplastics.com*** and ***www.materialdatacenter.com*** have technical data sheets from the different bioplastics suppliers. These databases contain detailed information on the mechanical and thermal properties of bioplastics, information on chemical resistance and other valuable information for the product development process.

Polyethylene and polypropylene are **commodity plastics**, with a low price point and properties that are not the top of the line but are perfectly sufficient for the products they are used in. The materials are often used in different kinds of packaging.

Polypropylene has characteristics that also make it a good choice for more advanced applications.

Structural plastics can withstand higher temperatures and a greater degree of mechanical stress and are more resistant to chemicals. The price per kilo goes up in line with these enhanced characteristics. Examples of structural plastics are polyamide and many materials in the polyester family.

Plastic packaging

Plastic is an important packaging material in the food industry, not least due to its ability to extend shelf life, thereby reducing food waste.

Plastic packaging is the single biggest product group for both bioplastics and fossil plastics in both single-use products and multi-use products. Within Europe, 58 per cent of bioplastics are used in packaging(*2018*).

To the furthest extent possible, bioplastic packaging should use prints with bio-based binders and pigments that are not harmful to the environment. Similarly, environmentally-friendly surface finishes should be chosen along with labelling that highlights the environmental profile.

The 2018 statistics from the Förpacknings- och Tidningsinsamlingen (*FTI*) packaging and newspaper industry association show that, on average, Swedish residents separate out about 7.5 kg of plastic packaging per year for recycling.

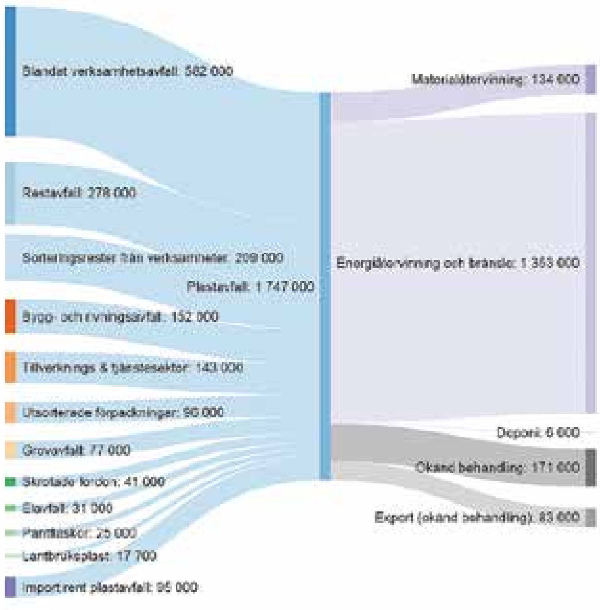
The recycling rate for the year was 42.2 percent, and a large proportion of the collected material was found to be at a quality level high enough that it can be recycled into new products. Therefore, the government's recycling targets for 2018 were met. ●

Image: Freepik.com

RECYCLING

More plastic needs to be reused and recycled as part of a circular economy. We need to move closer towards the sustainable management of resources, where we prevent the creation of waste and where waste that is generated can be reused, the Swedish Environmental Protection Agency states. It is also noted that, here in Sweden, a large portion of the plastic that cannot be recycled ends up being incinerated. A good deal of plastic is still ending up in the landfill as well.

In a circular economy, resources are kept within a closed loop, rather than ending up as waste. For plastics, this involves ensuring the material stays in circulation as long as possible before it reaches its final stop and is sent for energy recovery or material recycling directly through composting, whereby the material is returned to nature as biomass.



Plastflöden som avfall 2016/2017 (ton) och vad som skedde med plasten sedan. Totalt uppstod cirka 1,6 miljoner ton plastavfall

Durable plastics can generally go through material recycling up to seven times before the mechanical properties deteriorate to the point that the material does not serve the same function. The polymer chains become too short over time - just as the recycled fibres are shortened each time the plastic goes through material recycling. It then becomes time to manage the energy that has been contained in the material throughout its product life cycle.

Åsa Stenmarck, responsible for the investigation of durable plastics (*SOU: 2018:84*), notes that plastics offer many advantages along with a number of challenges.

The problem is that we are consuming more and more. Another factor is that the recycling process does not function optimally, which means that a lot of value is currently being lost from the system.

In order to create a sustainable, circular system, recycled plastic needs to become more competitive. This applies to both fossil plastics and bioplastics.

Different flows of plastic waste

The largest flows of plastic waste come from mixed waste and sorted residues from businesses (*791,000 tonnes*). The second largest flows are from residual waste, primarily residual household waste (*278,000 tonnes*), where plastic waste largely comes from packaging materials. Statistics show that the amount of sorted packaging is increasing. This number has increased from 26 per cent to 44 per cent, due to the fact that households are doing a better job sorting and recycling.

Then comes construction and demolition waste (*152,000 tonnes*) and sorted plastics from business activities (*143,000 tonnes*). The majority of construction and demolition waste goes to energy recovery.

Fossil-based plastics make up the overwhelming majority of the total waste volume, which could be replaced with sustainable bioplastics in many applications.

Quality-assured material

The need for quality-assured recycled plastic is great. In order to increase material recycling, it is important for producers and manufacturers to demand only the highest quality plastics, which can be easily separated from other materials and are free of hazardous substances.

The quality of recycled plastic can be as high as newly manufactured plastic—it all depends on the quality and purity. Many manufacturers avoid recycled plastics because they feel uncertain about availability and quality. Recycled materials are often used in conjunction with new materials to ensure a consistent raw material quality.

Thus far, there is no established common standard for recycled plastics, but the Swedish Environmental Protection Agency is working to develop guidelines for quality assurance.

Therefore, two conditions should be met to increase the use of recycled plastic – a fully functioning certification system for classifying plastic products and marking of plastic products for waste treatment.

Requirements for pure material streams

In order to be able to make new, high-quality products from recycled plastics, material streams need to be as pure as possible. Therefore, effective material sorting is crucial.

In order to simplify sorting at the consumer level, product marking is used—triangles with a number inside (*1 - 7*) or <x> where the plastic variety's abbreviation is indicated in clear text between the brackets.

The majority of the sorting is done in the larger plants using advanced analysis equipment, after which the various material types are handled and prepared to be reborn as new products. Materials that cannot be recycled for whatever reason are sorted out and continue to the energy recovery process, i.e., incineration.

Identification is done using NIR (*Near Infrared*) spectrophotometry, which is a technology that is also able to sort out bioplastics from mixed household waste.

A study performed by the German Ministry of Food and Agriculture(*BMEL*),shows that up to three per cent PLA by weight in recycled PP from household waste and up to ten percent PLA by weight in recycled PS does not noticeably decrease the quality of the recycled material.

The study also shows that at a higher proportion of PLA, separate PLA recycling streams become a more economically viable option.

Plastic waste is ground into smaller pieces in a mill (Photo: Rapid Granulator AB).

Black plastic can absolutely be sorted for recycling!

Rather than being sent for material recycling, high-quality black plastics are sent for energy recovery simply due to their colour. In the past, black plastics could not be sorted for recycling, since the carbon black that lends the plastic its black colour prevented identification of the plastic type.

This no longer holds true. An IR camera was recently launched that can identify all plastic types, regardless of colour. Another new approach is to replace old pigments with black pigments that do not interfere with traditional scanning technology.

Mechanical recycling

Mechanical material recycling is the term for the recycling process where plastic waste is decomposed/granulated in a mill to small granules measuring just a few millimetres, which can then be used for the manufacture of new plastic products.

In order to ensure the quality of mechanically recycled plastic as much as possible, it is especially important to prevent the mixing of different types of plastic. And purity is crucial.

The recycled material can be upgraded by adding new raw materials and additives when it is remelted before the material moves on to the plastic processor to be reborn as a new product.

Energy recovery

This is a type of recycling where the plastic waste is incinerated and the material's energy is used. This may be heavily soiled plastic or black plastic that cannot be classified, or it can be plastic products that have been sorted out for some other reason.

An established district heating network and energy-efficient waste-to-energy plants provide good conditions to recover energy from plastic waste. In this regard, biobased plastics can be likened to biofuels, as these plastics, much like wood, provide a much higher energy input than cellulose and also have the benefit of being carbon neutral.

Industrial composting

Organic recovery requires separate streams for composting and/or anaerobic degradation.

Industrial composting is not carried out within Sweden, since organic food waste is largely sent for digestion(*see the section further down in this chapter*) to produce biogas (*methane and carbon dioxide*), to be processed further into vehicle fuel and nutrient-rich digestate.

Other countries choose to invest in industrial composting instead. In Italy, for example, a country with a long history of processing compostable plastic, there are now almost thirty larger plants for this purpose.

Meeting the composting condition for industrial composting generally requires access to oxygen, along with balanced humidity and an elevated temperature. Home composting is not adequate for PLA in its pure form, but may be suitable for the starch-based plastics, PBS and PHA.

There is no overarching European standard for home composting, though some countries do have national regulations and certification programmes established for home composting.

European Standard EN 13432 (*for packaging*) and EN 14995 (*equivalent standard for non-packaging products*) defines the technical specifications for the compostability of plastic products.

EN 13432 establishes requirements for packaging materials, stipulating that these must be degradable through industrial composting. This is examined and approved through a testing programme along with evaluation criteria. The standard is harmonized with the European Parliament and Council Directive on packaging and packaging waste (*94/62/EC*).

In order for a plastic to be classified as compostable under EN 13432, four criteria, which describe the composting process, must be met.

Chemical properties - The plastic must consist of at least 50 per cent organic material and must not exceed the limit values for a number of heavy metals.

Biodegradability - The plastic must be fully degraded (at least 90 per cent) under controlled conditions, within six months. Biodegradation is defined as the conversion of organic carbon in the plastic to carbon dioxide.

Disintegration – The plastic (*in the form it is available on the market*) must disintegrate into fragments that are not visually (*<2 mm*) detectable within 12 weeks under controlled composting conditions.

Toxic to the environment - Compost, which at the end of the composting process, may contain residues that have not been broken down, must not have a negative effect on the environment (*germination and plant growth*).

Anaerobic digestion

In anaerobic digestion, bacteria break down organic waste into methane gas, carbon dioxide and digested material in a tempered, oxygen-free environment. The anaerobic digestion process is actually disturbed by oxygen, unlike composting, which requires oxygen.

Plastic bags that are broken down in an anaerobic digestion process are a sustainable alternative for managing food waste, but this requires that the material strictly meets the degradability requirements in an environment that differs from composting in a number of ways.

A report from IVL reviews experiments where different bioplastic bags used for food waste and paper bags are put into anaerobic digestion for 60 days. The bioplastic bags consisted of a mixture of starch and biodegradable polyester from plant-based oils. The results show that the plastic was not broken down to a significant extent. The conclusion from the report was that the degradable bags should be sorted out before anaerobic digestion, but additional process steps should be investigated. Secondary composting may be a viable option.

Methane is a product of anaerobic digestion, which can be used as an input material for the production of ethylene and propylene. Research is underway, and we can expect the commercial production phase sometime after 2030.

Chemical recovery

The process itself involves the gasification of plastic waste, whereby the molecules can be recovered and repolymerised. The end result of the process is a pure plastic product that maintains the original characteristics. This process is still under development and not yet in the commercial phase.

A major obstacle to the use of chemical recovery is the low price of plastics on today's market, so it does not make good financial sense(*even if it is environmentally beneficial*) to recover plastics through large-scale chemical recovery. Therefore, industry experts agree that policy intervention will be needed to make this method fully viable.

A CHEAT SHEET OF USEFUL TERMS

There are a range of abbreviations and terms that one needs to be acquainted with in the bioplastics field. We have therefore compiled a brief list of the most commonly used terms in this bioplastics guide.

Material abbreviations

PE .... Polyethylene

PP .... Polypropylene

PET ..... PET Polyethylene terephthalate – a polyester

PLA ..... Polylactide, a.k.a. polylactic acid– a polyester

PHA .... Polyhydroxyalkanoate – a polyester

PVC ..... Polyvinyl chloride

PA .... Polyamide

PC .... Polycarbonate

PTT ..... Polytrimethylene terephthalate

PEF ..... Polyethylene furanoate– a polyester

PBAT ... Polybutylene adipate terephthalate – a polyester

PBS .... Polybutylene succinate

Glossary

Aerobic degradation
Requires the presence of oxygen. During composting, microorganisms use the oxygen to convert organic material into energy (*heat*), carbon dioxide, water and biomass.

Anaerobic degradation
Degradation of organic matter through the action of microorganisms in the absence of oxygen. The biogases methane and carbon dioxide are formed, along with a solid residual product that can be composted in subsequent steps without generating heat. Both gases can be used as raw materials for the manufacture of bioplastic.

Bio-based
Describes a material or product that is fully or partially derived from biomass. This is indicated as a product's bio-based carbon content and biobased mass content. A biocontent percentage is indicated for biobased plastics along with the measurement method used.

Biodegradable plastic
Plastic that is fully assimilated by microorganisms, where the carbon contained in the plastic is fully converted to carbon dioxide during the microbial process. Biodegradability is dependent upon the polymer chain's structure, not the origin of the raw material. The degradation rate is dependent upon surrounding conditions, such as temperature and humidity. There is currently no single, overarching standard for biodegradability. One standard that is often referenced is EN 14995 Plastics – Evaluation of Compostability – Test scheme and specifications

Cellulose
The main component in cell walls in all higher order plants in varying amounts. This makes cellulose the most commonly occurring organic compound and the most common polysaccharide (*multi-sugar*). Cellulose is a polymer (*monomeric glucose*) with a very high molecular weight.

Carbon footprint
The net greenhouse gas emissions/uptake in a product system, expressed as carbon dioxide equivalents. Based on a life-cycle analysis.

Composting
Aerobic degradation of organic matter, i.e. degradation requiring the presence of oxygen to break matter down into energy (*heat*), carbon dioxide, water and biomass through the action of microorganisms. In order to be able to use the term compostable, certain conditions (*home composting, industrial composting*) and a timeframe must be specified. Several national and international standards are in place that provide a clearer definition. For the composting of bioplastics, this generally refers to industrial composting under the conditions defined in EN 13432. Degradation takes place at a steady temperature of about 60 degrees, with an optimal moisture content.

DIN-CERTCO
Independent certification organisation for the assessment/certification of bioplastics.

Drop-in bioplastics
Chemically identical to fossil-based plastic, but made with renewable raw materials. One example is bio-PE, which is produced from bioethanol from, e.g., sugar cane or partially bio-based PET, where the monoethylene glycol comes from bioethanol. Other examples are partially bio-based PA410 andPA610 as well as 100 per cent bio-based PA510 and PA 1010.

Fermentation
Biochemical reaction controlled by microorganisms or enzymes (*e.g., the transformation of sugar into lactic acid*).

Life-cycle analysis (*LCA*)
A summary and evaluation of a product's potential net environmental impact during its life cycle.

Organic recycling
The treatment of separately collected organic waste through anaerobic degradation and/or composting.

Polycaprolactone
A fossil-based biodegradable polyester used, e.g., for blending into renewable bioplastics to enhance properties.

Starch
A natural polymer (*carbohydrate*) from maize, potatoes, wheat, tapioca, etc. Starch is bonded by glucose in polymer chains. Thermoplastic starch (*TPS*) is a starch that has been modified into a plastic material.

TÜV Austria Belgium
Independent certification organisation for the assessment/certification of bioplastics. Formerly known as Vinçotte.

Wood-plastic composite
A composite of wood fibre/wood flour and plastic, usually polypropylene.

BIOPLASTICS MARKET DEVELOPMENT UPDATE 2019

Statistics from European Bioplastics

Dynamic growth: global production capacities of bioplastics 2019-2024

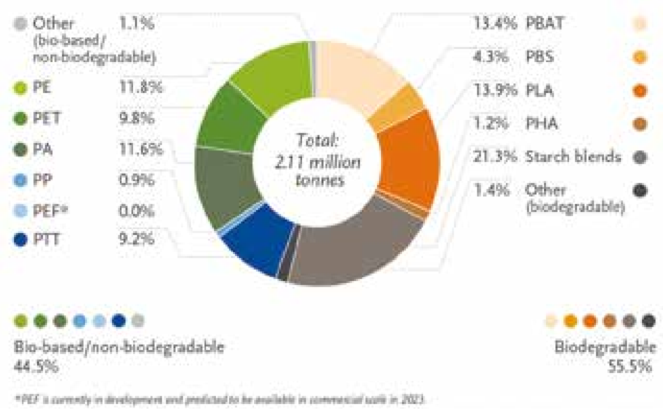
Bioplastics represent about one percent of the more than 359 million tonnes of plastic produced annually. But as demand is rising, and with more sophisticated applications and products emerging, the market for bioplastics is continuously growing and diversifying. Global bioplastics production capacity is set to increase from around 2.11 million tonnes in 2019 to approximately 2.43 million tonnes in 2024.

Global production capacities of bioplastics 2018-2024

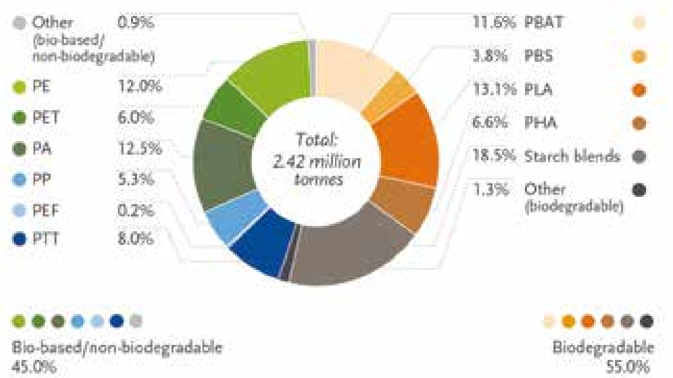
Material development and diversification

Bioplastics alternatives exist for almost every conventional plastic material and corresponding application. With further bioplastics materials being commercially available, the production capacities will continue to diversify within the next 5 years.

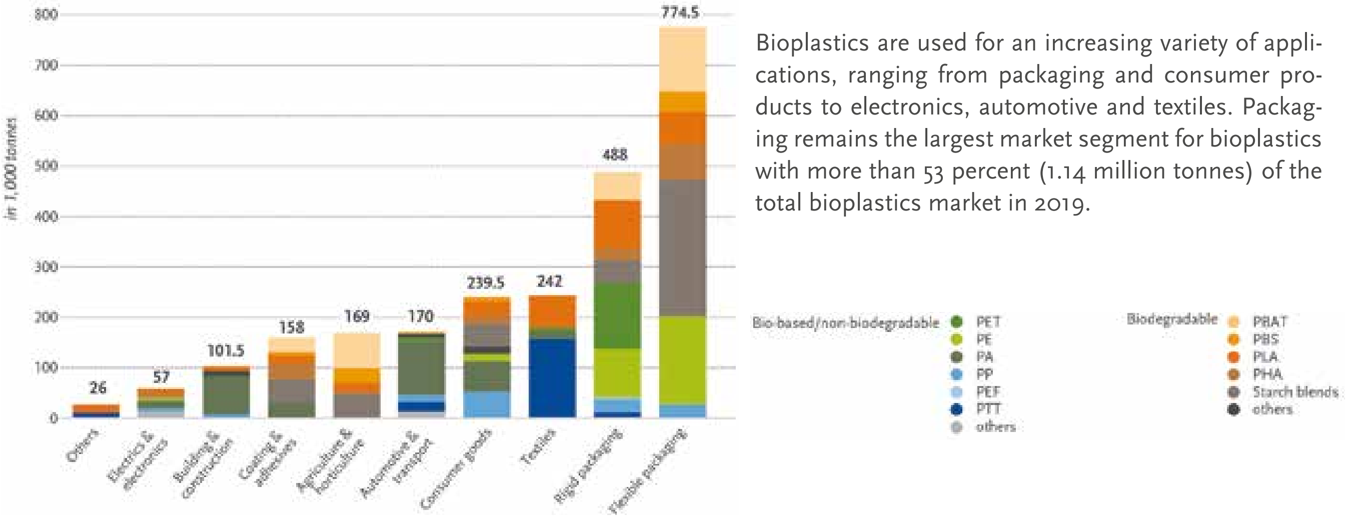
Global production capacities of bioplastics 2019 (by material type)



Global production capacities of bioplastics 2024 (by material type)



Global production capacities of bioplastics 2019 (by market segment)



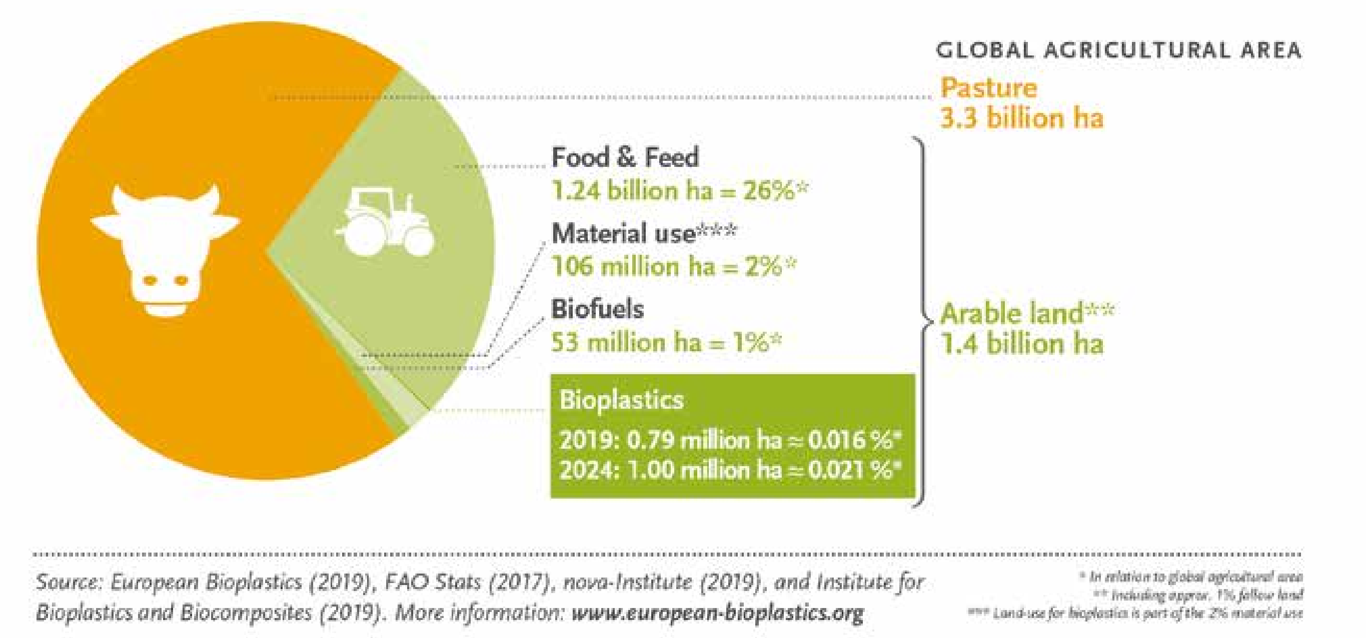
Applications and market segments

Bioplastics are used for an increasing variety of applications, ranging from packaging and consumer products to electronics, automotive and textiles. Packaging remains the largest market segment for bioplastics with more than 53 percent (1.14 million tonnes) of the total bioplastics market in 2019.

Land use share for bioplastics estimated to stay at 0.02 percent

The land used to grow the renewable feedstock for the production of bioplastics remains at approximately 0.79 million hectares in 2019. This accounts for 0.016 percent of the global agricultural area of 4.8 billion hectares. Despite the market growth, the land use share for bioplastics will only slightly increase to 0.021 percent until 2024. This indicates once more that there is no competition between the renewable feedstock for food and feed, and the production of bioplastics.

Land use estimation for bioplastics 2019 and 2024



About this market data update

The market data update 2019 has been compiled in cooperation with the market experts of the nova-Institute (Hürth, Germany). The market data graphs are available for download on http://www.european-bioplastics.org/news/publications/

european bioplastics

Driving the evolution of plastics

INTERNATIONAL CERTIFICATION

European
certification brands

Australian and **North American**
certification brands

By adhering to proven scientific and organisational standards, companies are protected and we get an accurate comparison of test results. Certifications are a way to show that these rules have been followed and are a better way to inform users of the product's characteristics.

TUV certification: OK Compost

The label OK compost INDUSTRIAL guarantees compliance with European standard for compostability in industrial composting *(EN 13432)*.
The products are only compostable in industrial plants
(at temperatures of 58 °C +/- 2 °C for six moths; 90 per cent must be broken down in an aerobic environment)

OK Compost HOME guarantees biodegradability in home garden compost.
The products are also compostable at lower temperatures
(at a max ambient temperature of 30 °C for one year; 90 per cent must degrade in an aerobic environment)

BIODEGRADABILITY

OK biodegradable MARINE ensures degradation in sea water,
which contributes to the reduction of marine debris.

OK biodegradable WATER ensures degradation in fresh water and contributes to reduced pollution of lakes, rivers, chines and streams *(90 per cent must be degraded within 56 days)*
Note that this does not automatically guarantee biodegradability in a marine environment.

OK biodegradable SOIL guarantees that the product will degrade completely without negatively impacting the environment. Decomposition occurs within three months, total biodegradation within three years.

PRPORTION OF BIO-BASED CONTENT

OK biobased is a certification system that verifies
the proportion of bio-based content in a product according to the following:

between 20 and 40% biobased	between 40 and 60% biobased	between 60 and 80% biobased	more than 80% biobased

REFERENCES

Thiele, M. Bioplastics: Basics, Applications, Markets, Polymedia Publisher (2012)

Schöning, D. Sustainable Solution for Coloration of Bioplastics, Akro-Plastic GmbH (2014)

Örnskär, H. Har nedbrytbar plast en plats i samhället, examensarbete i miljövetenskap, Lunds Universitet (2018)

The New Plastics Economy – Catalysing Action, Ellen MacArthur Foundation (2017)

PLA in the Waste Stream, Fkur (2017)

Guide för bioplaster – från tillverkning till återvinning, Cefur – Center för forskning och utveckling i Ronneby (2016)

Environmental Communication Guide, European Bioplastics (2017)

Communication on Sustainable Consumption and Production and Sustainable Industrial Policy Action Plan, European Commission (2008)

ISO 14067. Carbon Footprint of Products – Requirements and guidelines for quantification and communication

ISO 14044 Life Cycle Assessment

CEN TR 15932. Plastics – Recommendation for terminology and characterisation of biopolymers and bioplastics (2010)

CEN/TS 16137. Plastics – Determination of bio-based carbon content (2011)

EN 13432. Requirements for packaging recoverable through composting and biodegradation. Test scheme and evaluation criteria for the final acceptance of packaging (2000)

www.european-bioplastics.org* • *www.nordiskbioplastforening.se* • *www.wikipedia.com

The information in this publication has been produced by ***Katarina Elner-Haglund***, Master of Science in engineering with a focus in polymer technology. She has extensive experience in the plastics industry and established relationships with the industry's customers through her work as an educator in material science and plastic design. She is also a teacher in the Product Development/Design Sciences department at Lund Faculty of Engineering (LTH), where the future engineers of the world learn more about plastic.

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NORDISK BIOPLASTFÖRENING

NORDIC BIOPLASTICS ORGANISATION strives to become the Nordic region's platform for bioplastics and the voice of the Nordic bioplastic companies. The association strives to promote and simplify market trends and technological developments for the material group. Our activities shall cover all parts of the bioplastic life-cycle, from cradle to grave.

We also strive to effectively lobby politicians and authorities to inform them of the possibilities and benefits offered by the materials we promote, and to assist in the creation of a framework to advance bioplastics on the market. Our active efforts to promote a functioning and effective framework is one of the association's primary tasks.

Our objectives also include the establishment of media contacts, informing media representatives in all matters relating to bioplastics and working to ensure the media publishes information relating to the material group in an accurate and positive way.

Nordic Bioplastics works to build and maintain a network between the actors in the industry and will work to promote increased collaboration between companies and to continue and increase reciprocal engagement with the research sector and academic world. Our member's customers are also invited to become members of the association.

Nordic Bioplastics has an established relationship with European Bioplastics, which is based in Berlin and is a member of BON (Bioplastics Organizations Network Europe) and holds several annual meetings for the exchange of experience and discussion of current issues in the industry. Nordic Bioplastics is one of Europe's largest bioplastics associations.

www.nordicbioplastic.com

european bioplastics

EUROPEAN BIOPLASTICS is an organisation that works to reinforce for the role of bioplastics in reducing dependence on fossil resources, to reduce harmful greenhouse gas emissions and to promote the more efficient use of renewable raw materials.

The Industrial Association was founded in Germany in 1993 and works to safeguard the interests of the European bioplastics industry. Members come from the agricultural, chemical and plastics industries along with recycling companies and brand owners.

The organisation functions both as a communication platform and a catalyst to promote development in the rapidly growing bioplastics industry.

The organisation has put together a guide for environmental communication relating to bioplastics, ***Environmental Communications Guide*** *(https://bit.ly/2Xs9Xc9)*.
Here, you will find detailed information about relevant standards, certifications and markings. There are also general recommendations and specific guidelines for promoting effective communication around bioplastics.

www.european-bioplastics.org

MEMBERS OF
NORDIC BIOPLASTICS ORGANISATION

(64 companys – January 2020)

AB Kulleborn & Stenström
Addvanze AB
ALBIS PLASTIC Scandinavia AB
Alsiano AB
Arctic Biomaterials Oy
BASF A/S
Bio Plastic AS
Biobag Sverige AB
Bioextrax
Biofiber Tech Sweden AB
BK PAC AB
Boxon Pak AB
Creopack AB
ELNER Communication
Emballator Mellerud Plast AB
Emballator Växjöplast AB
FKuR Kunststoff GmbH
GAIA BioMaterials AB
Hexpol TPE AB
ICBP
Iggesund Paperboard
IKEA of Sweden

IMCD Sweden AB
Improve Tec Hönö AB
LEVE PLASTPRODUKTER
Light My Fire Sweden AB
Mälarplast AB
Miko Plast AS
Mondi Örebro AB
Nemco AB
NNZ Scandinavia
Nolato AB
nord emballage
Nordic Pack Förpackningar AB
Nordiska Plast AB
Novamont SPA
OPEA Solutions AB
Orthex Sweden AB
Papstar AB
Paxxo AB
PERSTORP AB
Plastiroll Oy
Polymer Front AB / FKuR
Polynova Nissen AB

Pont Packaging Scandinavia
Procurator
RPC SUPERFOS LIDKÖPING AB
Rullpack AB
San Sac AB
Scanfill AB
Segerstein´s Design & Pack AB
SOLE SW AB
Stora Enso Timber AB
Svenska Industriborstar i Västerås AB
Swedish Match North Europe AB
Testfakta Bio-based Europe AB
Tetøsene AS
Treform Packaging AB
Trifilon
Walki Oy
WeLoc - Weland M. AB
Wiitta Oy - We Love Plastics
Wildo Sweden AB
Wold-Trade

NORDISK
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