

**TOP
DUTCH**

**A good place
to be great**



THE NEW PLASTICS ECONOMY

How TopDutch is closing the plastics loop

Plastic is fantastic. It keeps food fresh, makes planes and cars lighter and therefore more energy efficient, and can be transformed into an infinite range of products. However, the increasing scale of production and the disposable manner of the use of plastic, is now also clearly causing a lot of misery. Plastics are made from oil. Plus, large amounts of waste turn our oceans into a *plastic soup*. So how do we make plastics fantastic again? The Ellen MacArthur foundation outlined three ambitions for the New Plastics Economy. This document explores the promising innovations that are emerging in the Netherlands. Here, it is the TopDutch region that is leading the *New Plastics Economy*; heading towards becoming 100% circular.

**THE NEW PLASTICS
ECONOMY:
HOW THE
TOPDUTCH REGION
IS TAKING THE
LEAD IN CLOSING
THE PLASTICS
LOOP**

The plastic soup

The disastrous consequences of discarded plastic regularly make news headlines. We've all seen the carcasses of dead waterfowl with their stomachs full of plastic on TV. Or the paradise beaches of Bali, dotted with tons of plastic, washed ashore from the sea. It can't be ignored: our oceans are slowly turning into a floating garbage dump. The sea current causes plastic to gather in a number of places in the world's seas. The largest plastic soup, the Great Pacific Garbage Patch (GPGP), is located between Hawaii and California and is three times the size of France.

Time to clean up

A Dutch 24-year-old, Boyan Slat, initiated the Ocean Clean-Up: a large-scale project to clean up the plastic soup. He invented and developed a 'plastics catcher'; a 600 meter long floating tube, with a massive sieve attached to it that collects the waste, after which a ship cleans up the rubbish. His idea was so popular with international investors, that the Dutchman could actually start building it. In October 2018, the Ocean Clean-Up was launched in San Francisco and should significantly reduce the plastic soup over the next five years.

Plastic is everywhere, also where it shouldn't be

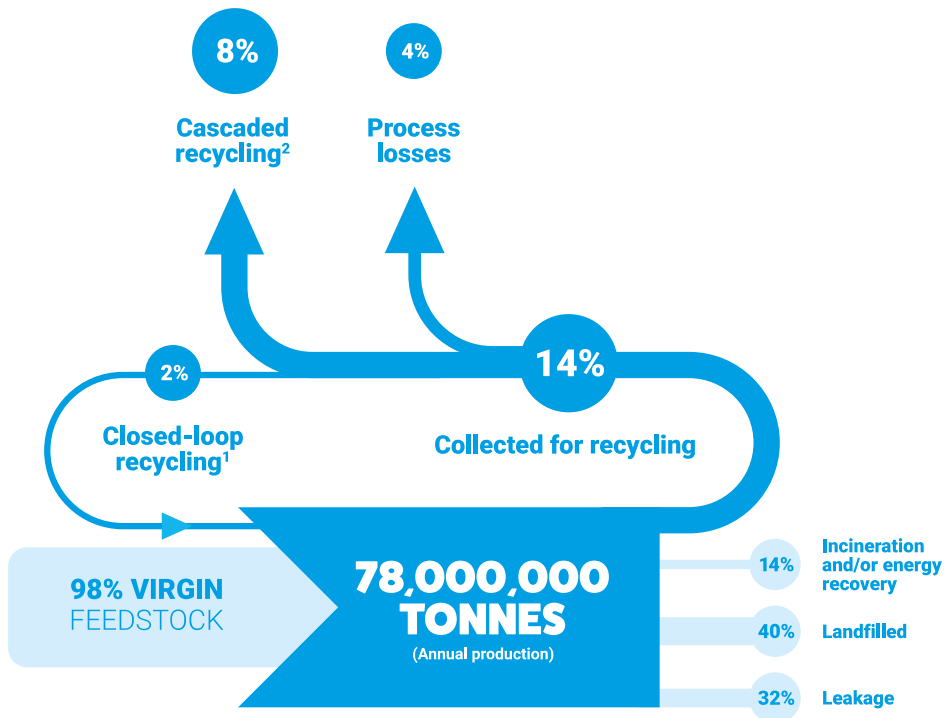
But what is plastic and why is it so harmful? To answer that question, we should start with a chemistry lesson. Plastic consists of polymers. These are large molecules made up of a series of small molecules: the monomers. Polymers are produced by chemical - or non-natural - processes. Polymers are often complex molecules that are not found in nature. So, if they end up in the sea or in the forest, they are barely biodegradable. And therein lies the biggest problem. Plastics roam around for years, and are now visibly polluting our planet. Plastics often break down into micro-particles that end up in the farthest reaches of the world - Japanese researchers even found micro-particles in the Mariana Trench in the Pacific Ocean, at a depth of 10,000 meters. The plastic particles also end up in our food chain, and thus, in our bodies. The effect of this on our health is still unclear.

In 2017, the Ellen MacArthur Foundation outlined a shocking picture of the future. If we will not be more careful, by 2050 more plastic will be swimming in the sea than fish. The British foundation, that seeks to stimulate the circular economy, calculated that every year at least 8 million metric tons of plastic end up in the ocean. That is equivalent to one garbage truck per minute. If we don't implement measures, this number will rise to four per minute in 2050.

As if that were not enough, plastic has a second worrying side effect: plastic production requires oil, the fossil fuel that contributes to CO₂-emissions. Each year, the production and incineration of plastics emits around 400 million metric tons of CO₂ worldwide.

Today's plastics economy

Source:
Ellen MacArthur Foundation



1 Recycling of plastics into the same or similar-quality application

2 Recycling of plastics into other or lower-value applications

Closing the plastics loop

That has to stop. The huge impact of plastic pollution on our environment means that we have to change course. The good news is that we can create a future that will bring less 'plastic pain'. In 2017, the Ellen MacArthur Foundation presented the plan for a '*New Plastics Economy, Rethinking the Future of Plastics*'. According to this vision, our disposable economy must be transformed into a circular economy, in which plastic is retained as a raw material. A society in which the plastic cycle is closed not only provides us with a cleaner environment, but also a financial benefit. The foundation calculated that 95% of all packaging plastic is currently lost to the economy after use, a loss of 80 to 120 billion dollars.

Three ambitions of the new plastics economy

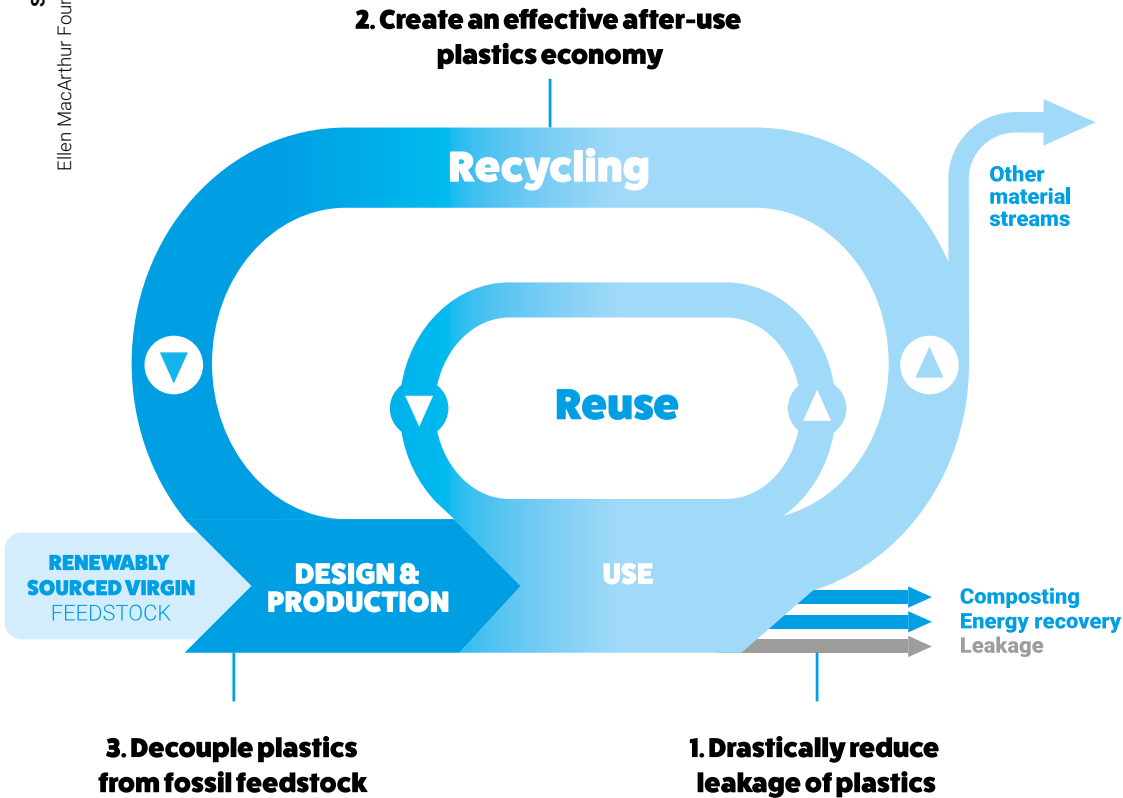
Sounds great, but how do we arrive at a New Plastics Economy?

The report of the Ellen MacArthur Foundation formulates three ambitions:

- 1. The leakage of plastic to nature must be drastically reduced.**
- 2. Recycling of waste plastics must become more economically attractive.**
- 3. Plastics must be developed that are no longer made from oil.**

The new plastics economy and its three ambitions

Source:
Ellen MacArthur Foundation



TopDutch region: the hotspot for polymer knowledge

In the Netherlands, a New Plastics Economy is rapidly taking shape. That should not come as a surprise: the country leads the way in plastic recycling. According to figures from PlasticsEurope, the plastics industry association in Europe, the Netherlands - together with Germany, Norway, Sweden and Denmark - is one of the top five countries with the highest recycling rates.

In addition, it has renowned knowledge institutions, which are looking for sustainable alternatives to oil-based plastics. The focus is particularly strong in the TopDutch region. At Chemport Europe, the Chemical Cluster Emmen specifically, traditionally produces polymers, plastics and fibers. There is ample knowledge of polymers and fibers. For some years now, there has been a huge ambition to green these raw materials for plastics - or to recover them from plastic waste. The great advantage of the TopDutch region is that knowledge institutions and the business community work closely together. Potential technologies are jointly tested and, if desired, scaled up to a pilot plant. Support from local authorities is also essential. Regional governments are investing heavily in the greening of its chemical clusters.

Time for an exploration. We will now outline the steps the TopDutch region has already taken towards a New Plastics Economy and experts will tell us about the innovations that have taken off, but also about the challenges that lie ahead.

1.

REDUCE
THE LEAKAGE
OF PLASTICS
INTO NATURE

It's widely known that the collection of plastic is extremely poor worldwide: according to figures from the Ellen MacArthur Foundation, only 14 percent is collected. The infrastructure for waste processing is especially poorly developed in Asia. Most plastic ends up in a garbage dump, or worse, in the ocean. Asia is responsible for 82 percent of the leakage to the sea. Europe and the USA accounts for only 2 percent of leakage into oceans, the rest of the world for 16 percent.

Master the collection of plastics

The Netherlands scores exceptionally high when it comes to plastic collection. Thanks to a deposit scheme, no less than 95% of the PET bottles used are returned. Since 2007, Dutch households have also been separating their plastic packaging waste. An important step: of all plastics produced, about 40% is plastic packaging. Thanks to the Plastic Heroes collection system, collection increased from 25.2 ktonnes in 2009 to 162 ktonnes in 2014. The collection system is an initiative of packaging companies and is now implemented by almost all Dutch municipalities. As a financial incentive, municipalities are paid per metric ton of recycled plastic.

95%



In the Netherlands, 95 percent of PET bottles are returned. Thanks to our deposit scheme, Dutch households are used to returning plastic bottles.

2009

25.2
ktonnes

2014

162
ktonnes



**Thanks to the Plastic Heroes campaign,
Dutch plastics' collection increased
from 25.2 ktonnes in 2009 to
162 ktonnes in 2014.**

But the Netherlands wants to improve its collection process even further. Following the example of other European countries, the Netherlands is considering levying deposits on smaller PET plastic bottles. This deposit scheme will however only be introduced if the industry fails to reduce the proportion of one-liter PET bottles by at least 70% by January 1st, 2021. The Dutch government also obliges the industry to reuse 90% of the collected plastic.

Put a ban on disposable plastic

The plastics problem is high on the European agenda. The European Union recently decided that from 2021 onwards, a ban will be introduced on single-use plastics, such as straws, cutlery, stirring sticks and cotton swabs. Disposable plastic bags have been banned in Europe since 2016. This measure had an impact: the amount of plastic bag waste in the North Sea has since more than halved. Countries outside Europe are also banning disposable plastic. Costa Rica introduced a ban on disposable plastic in 2017. In Asia, India seems to be taking the lead on banning disposable plastic, having recently announced its intention to ban disposable plastic from 2022.

**40 percent of all globally produced
plastics are used for packaging.
Used just once and then discarded.**



2.

**MAKE
RECYCLING
PLASTICS
ECONOMICALLY
ATTRACTIVE**

An efficient and, equally important, profitable recycling industry is essential for the creation of a New Plastics Economy. The dream scenario is to completely close the plastics cycle, so that no raw materials are lost. There's still a long way to go with that: according to the report of the Ellen MacArthur Foundation, only 10 percent of all plastics worldwide are recycled. The recycling rate was 39.1 percent in 2015 in Europe and 9 percent in the United States, according to figures from the United States Environmental Protection Agency. The rest is incinerated, ends up in a landfill or, even worse, in nature.



55%

In the Netherlands, 55 percent of all plastic packaging is recycled. Dutch households and companies separate plastics from other waste, so it's easily collected for recycling.

Internationally, the Netherlands scores high with a 55 percent recycling rate for plastic packaging in 2017. But the country still sees plenty of opportunities to improve.

The big breakthrough: chemical recycling

A promising innovation is chemical recycling of polyester (PET), a technology that is being extensively tested in the TopDutch region. 'This technology makes it possible to transform the most polluted and colored PET plastics into new raw materials of the original quality. A big breakthrough', says Jan Jager, lecturer in sustainable plastics at the NHL Stenden University of Applied Sciences in Emmen. 'So far, food packaging recycling has been done mechanically. This technique, which consists of washing, grinding and melting into new products, is extremely suitable for recycling PET bottles. But the technique is inadequate when it comes to items such as colored PET or colored polyester textiles.' According to Jager, household plastic waste is often too dirty, and varies in color and composition. Large quantities end up in the incinerator. 'In chemical recycling of PET, impure plastic is no longer a problem. In this process, the polymers are converted by a simple chemical reaction into the original building blocks from which new polymers can be made. That means big profits; a large stream of polluted plastics can be kept in the cycle thanks to chemical recycling.'

'With chemical recycling, we can transform even the most polluted PET plastics into new raw materials for plastic. A major breakthrough'

Jan Jager, Lecturer in sustainable raw materials

The chemical recycling of PET plastics was a research project in which the company Cumapol from Emmen collaborated with three knowledge institutions. These were NHL Stenden University of Applied Sciences and Windesheim University of Applied Sciences, united in Green PAC, and the University of Groningen. Initially, the technique was tested on a small scale, within the walls of the educational institutions. The next step is to try the technology at the Cumapol plant. The company will be starting this year with a pilot production line where PET is chemically recycled.

This is a good example of how innovation finds fertile soil in the TopDutch region. Thanks to the short lines between the business community and knowledge institutions, various innovations have already been made.

Enabling endless reuse of plastic

Cumapol originally produced polyester granules with oil as a raw material for the production of articles such as PET bottles, yarns and packaging. 'That's no longer necessary. Thanks to this new form of recycling, we'll soon be making exactly the same granules, but now with polyesters extracted from household waste,' says director Marco Brons. This makes Cumapol an international leader. Brons says: 'The big advantage is that the raw material we obtain from chemical recycling can be used endlessly. This is not possible with mechanical recycling.'

According to the entrepreneur, this recycling method tackles what has, up to now, been a major problem. 'Plastic processors often do not trust the quality of colored recycled PET and therefore - also because of the low price - often choose new plastics. Up to now, demand for recycled plastic has accounted for only 6% of the demand for plastic in Europe.'

There is another plus: 'According to the Commodities Act, non-food packaging may only be processed into new food packaging after chemical recycling. In that respect, too, the plastic retains its value.' According to Brons, the process of chemical recycling is reasonably simple in its basic form: 'Polyesters consist of long chains of monomers. By adding a great deal of ethylene glycol, which is one of the monomers, the chains

disintegrate and a liquid is created that is easy to purify. We then remove the ethylene glycol and are left with clean PET granules.' Over the next three years, Cumapol will refine the technology and will do so together with the knowledge partners involved.

Mechanical and chemical recycling are both economically viable

'The new recycling method will be integrated into the existing Cumapol plant. This production line will process 25 metric kton per year.' Also, since 2013, a line has been running with mechanical recycling of PET bottles.

'This older technique is still preferred because it is cheaper and has a lesser CO₂-impact', says the Cumapol director. Although more expensive, he believes that chemical recycling is economically viable because there are currently sufficient waste streams available. This is thanks to the national collection of the packaging industry, known as 'Plastic Heroes'. Since 2008, the initiative has been collecting large quantities of household food packaging every year. To ensure a continuous supply, Cumapol works together with two local waste processors, who guarantee that Cumapol is never wanting for residual flows. 'The line must run 24 hours a day, only then is it profitable.' Cumapol's long-term goal is to further green the chemical recycling process and to reduce CO₂-emissions.

Design to recycle

A circular economy, in which all residual streams are endlessly reused, comes a step closer if we start designing some packaging differently. Packaging materials are divided into seven categories, of which category 3 (polyvinyl chloride or PVC) and 6 (polystyrene) are difficult to recycle. The latter often ends up in an incinerator.

According to the Ellen MacArthur Foundation, about 30% of packaging materials are not or are only barely recyclable. Packaging producers will have to find alternatives with innovative products. Political ambition is also alive in Europe. According to the Plastic Strategy presented by the European Union in 2018, all packaging materials must be recyclable by 2030.

Standardizing plastics would also be a big step forward, according to Jan Jager, lecturer of sustainable raw materials at NHL Stenden University of Applied Sciences. 'Packaging plastics often consist of too many layers or have unwanted additives. We have to get rid of that. It would help if producers had to keep to a limited number of plastics according to an agreed standard.'

Innovation: recycle the unrecyclable

But there is still a large group of plastics that are difficult or impossible to recycle. Unlike thermoplastics, which are used to make packaging materials, thermohardners cannot be melted down and turned into something else when heated. Examples include hard plastic, such as in sockets, tennis rackets, surfboards, sailing boats. The group of elastomers or rubbers, such as roofing for houses, bicycle and car tires, are also difficult to process into new raw materials. At least, not in the way they have been currently been produced.

**'The challenge is to develop bioplastics
that perform better than traditional plastics.
Biobased is not enough'**

Francesco Picchioni, Professor of Chemical Technology

In the TopDutch region, we have been working on innovative products for some time now. And not without success. The research group of Francesco Picchioni, professor of chemical technology at the University of Groningen, discovered that rubbers can be recycled into a high-quality new product if they are produced in a different way. Picchioni explains: 'Rubbers are currently made by connecting long polymer chains via sulphur compounds. That process is called vulcanization. The problem is that these compounds can no longer be broken down without destroying the polymers themselves. We have used other compounds instead of sulphur compounds. In this way, the chains can be cracked at low temperatures.'

'We won't be winning a Nobel Prize with the invention', Picchioni laughs, 'but, it does mean a breakthrough. In the future, we will be able to keep all kinds of rubber in circulation. The recycling of car tires in particular is a gain.' Worldwide, approximately one billion car tires are discarded each year. They end up as a weight on top of tarpaulins or as swings in playgrounds. Their sole last use is being processed into soft play tile, under the swings or climbing frames. After that, they can't be recycled any further, so end up in the incinerator. With the newly developed rubbers, this will no longer be necessary.

3.

**STOP MAKING
PLASTICS FROM
FOSSIL RAW
MATERIALS**

The plastic soft drink bottles on the supermarket shelves are produced with oil in large quantities every day. There's no need for that. **PET bottles can also be made from sugars from sugar beet and cane**, as demonstrated by the Dutch technology company Avantium, with a branch in Delfzijl. In three years' time, the company will open a commercial factory to produce the sugar bottles. Lactic acid is also a new, natural raw material for bioplastic, a technology from another Dutch company Corbion, which recently started producing bioplastics in Thailand. The company Cumapol referred to above also has a world first. The polyester manufacturer succeeded, together with the company BioBTX, in being the first to produce 100 percent bio-based polyethylene terephthalate. This is the raw material that is often used for items such as the well-known PET bottle. According to Cumapol director Marco Brons, 'several hundred' kilos of the bioPET should be produced in 2019.



Cumapol Director
Marco Brons



Bio-based plastics

The first steps towards bioplastics are being taken. But the share is still small; only 1% of the plastics produced come from biomass. 'That's going to change quickly', says Francesco Picchioni, professor of chemical technology. 'Within a few years, many large companies will switch to sustainably made plastics.' Picchioni should know; he is involved in various research projects, with larger companies as partners. A recently completed project is *Beets to biopolymers* in partnership with Royal Cosun and electronics group Philips. The search was for chemical building blocks from sugar beet pulp that can be used to make high-quality plastics.

The challenge in any project is to develop bioplastics that perform better than traditional plastics. *Biobased is not enough*, is Picchioni's motto that he also likes to tell producers. 'Oil-produced plastics are still cheaper than green plastics, so as a producer of bioplastics you should not compete on price, but be able to offer added value.' Picchioni is convinced that there is a market for films that keep food fresh for longer or have an antibacterial effect. 'The great advantage of chemicals from biomass is that they naturally already have various functionalities. This makes it easier to give bioplastics a distinctive character. This is not the case with plastics made from *virgin materials*. You need an extra chemical process to add such a property.' Picchioni tells us.

'Manufacturers who produce only oil-produced plastics, will run into problems and see their market share decline'

Cumapol Director Marco Brons

Building the future with biocomposites

In recent years, the TopDutch region has also developed into a knowledge center for biocomposites. Five years ago, the region had a world first by building a lifting bridge from natural materials. Natural fibers from the flax plant were used in combination with bio-resin. Eco-friendly and also lighter and more durable than steel. The bridge was placed in the Emmen Zoo Wildlands. Two years ago, the municipality of Emmen was also given a bicycle path made of biocomposite, made of wood fibers and a bio-resin. Lecturer Jan Jager explains that new research projects into new applications of biocomposite are currently underway with various partners.

When plastics do leak into nature...

Finally, in a *New Plastics Economy*, the development of compostable plastics is also of great importance. 'It is utopian to believe that plastics will never again end up in the sea or in nature, which is why we need to develop plastics that do less damage if they do get into nature', says Jager. Here too, there is still a major challenge. Although, again from the Northern Netherlands, there are innovations. The company Senbis Polymer Innovations from Emmen has already developed compostable twine for the horticultural sector. Previously, the twine used for growing tomato or pepper plants was made of traditional plastic that remains in the soil. The company marketed a similar product for trawler fishing: a degradable rope that protects fishnets against wear. The fibers of this bio-rope are broken down by bacteria in the sea within a few months to CO₂ and water. And Senbis is continuing to innovate. The company is working with ten researchers on the development of all kinds of sustainable plastics.

Making plastics fantastic, again

According to plastics experts, the *New Plastics Economy*, with less impact on the environment, is possible. Cumapol director Marco Brons is confident about the future of plastic. 'Ultimately, the demand for recycled raw materials and, accordingly, products will increase. The industry will therefore have to take steps.' Brons believes: 'Manufacturers who produce only oil-produced plastics will run into problems and see their market share decline.'

Until then, University of Groningen Professor Picchioni says, the low oil price is causing havoc. 'For producers, the temptation is still too great to make new plastics. Making plastics from biomass or recycled plastic is often still too expensive.' Picchioni would also like to see the Netherlands tax plastics that cannot be recycled. It makes no difference whether they are made from fossil raw materials or from biomass. Finally, Picchioni believes that governments should invest more in innovation. The TopDutch region has understood this well. In the northern part of the Netherlands, companies, knowledge institutes and governments are working together to give new technologies a chance. Companies take the initiative to make technologies

succeed if they see a business case in them. The role of the northern provinces and, for example, the Dutch Investment and Development Company for the Northern Netherlands (NOM) is essential in this respect. If a technology has proven itself, they help entrepreneurs with subsidies or financial capital to build a first pilot plant. This creates a flywheel effect. By combining forces, the TopDutch region is taking the lead in the *New Plastics Economy*.

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