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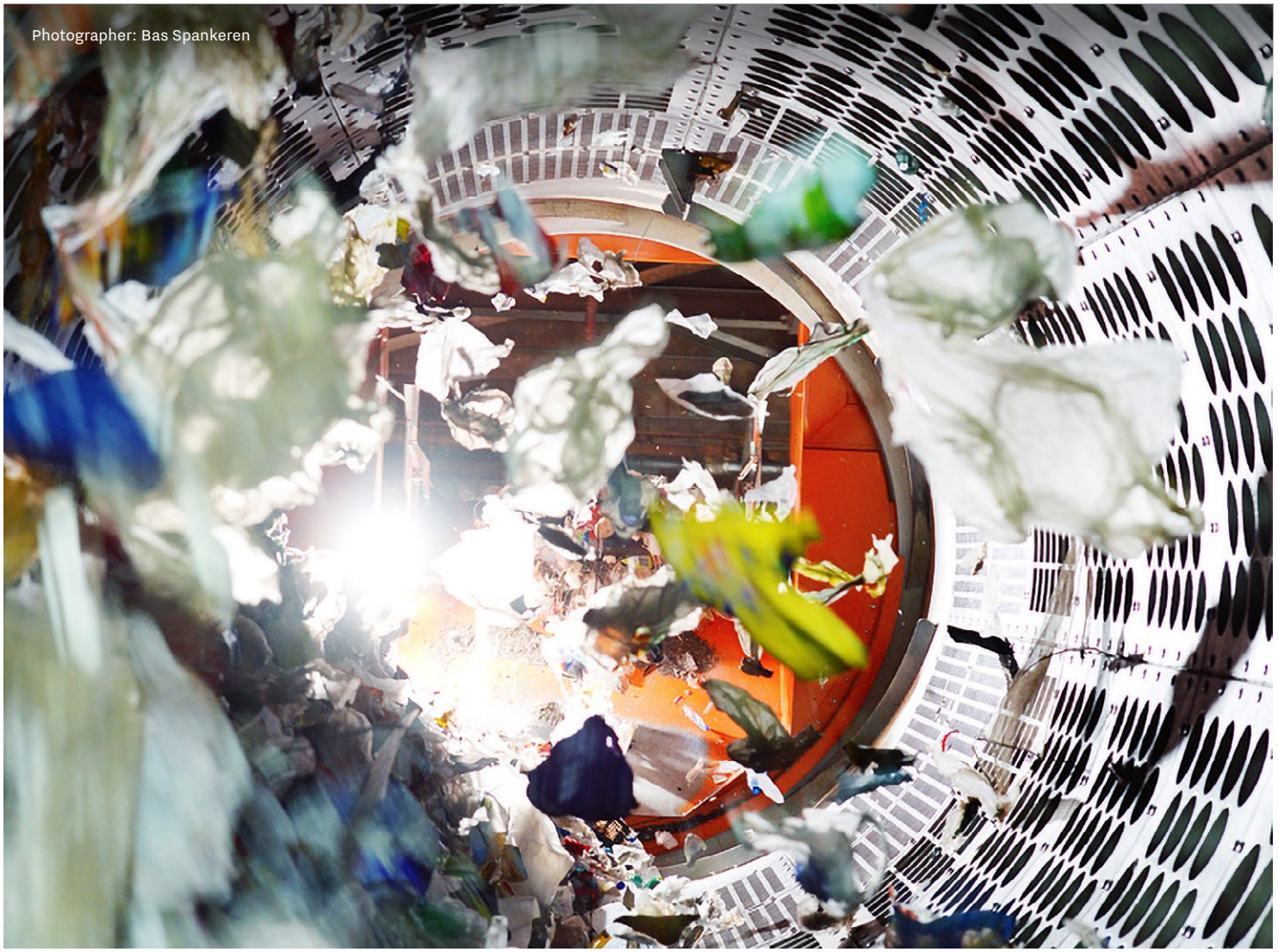

A circular economy for plastics

Lets turn challenges into opportunities

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Preface

We all know that plastic is a miracle substance. It's strong, light, flexible, easy to use. But we know about its disadvantages. We are still landfilling or incinerating more than 70% of our plastics too in Europe. And more than 90% globally. Way too much plastic is ending up on our streets, in our rivers and in our oceans. It's time to change the game. To start treating plastic as the valuable raw material it is. Waste is a human invention, one which we can do without! And we have the solutions. We can do much better!

The problems associated with plastic waste and pollution are increasingly attracting the attention of the public, governments and businesses around the world. Many have already taken action. At the national level, countries have developed their own strategies, such as the national Plastics Pacts in the Netherlands, France, the UK, Poland and Portugal. At the European level, the Circular Economy Action Plan provides the framework, alongside legislation, guidelines and collaborative innovation platforms, such as the European Plastics Pact and the Circular Plastics Alliance. Finally, key initiatives are undertaken at the global level, including the UN Global Partnership on Marine Litter, the Basel Convention, the European Plastic Pact, the Global Plastic Action Partnership, the Global Alliance to End Plastic Waste, the Platform for Accelerating the Circular Economy and the Ellen MacArthur Foundation's Plastics Pact Network and the New Plastics Economy Global Commitment.

More and more producers and retail companies are aware that they can't operate anymore in a linear economic system. Customers hold these companies accountable. They demand corporate action, showing transparently that they reduce, reuse and recycle plastics as much as possible. Governments are confronted with the effects of the throwaway society. And civil society demands governments and businesses to develop a proper waste infrastructure, in order to create a clean and healthy environment, cutting CO2 emissions at the same time.

So, there is momentum. All of us, governments, companies and civil society alike, are trying to become smart and efficient in our use of plastics: in the design phase of production, the use phase of consumption and in the waste treatment phase. As you can read in this brochure, the challenges to master the use of plastics are complex. At the same time, I am convinced that together we will find creative solutions, to minimize the environmental impact of the production and use of plastics and to preserve their value as much as possible. We all have to invest in an innovative waste infrastructure, leading to high performance recycled plastic materials, reusable and recyclable by default.

The Netherlands is at the forefront of many of these processes. By joining forces, Holland Circular Hotspot and TNO, have shared their insights, networks, sharing the stage with innovative entrepreneurs, concisely in this brochure. I hope that it will inspire you all to take action also in other parts of the world and kick-start circular development. Do not hesitate to contact the authors for further information.

With your support and the growing bold movement of public-private networks worldwide, we will be able to make the transition towards a circular and climate neutral plastics economy, together!

Stientje van Veldhoven,
Minister for the Environment

Chapter 1

Intro

Plastic is an amazing substance, an amazing, versatile invention – lightweight, tough, transparent, waterproof. Plastic is also one of the largest environmental threats facing our planet. The business-as-usual scenario is not an option anymore for plastics. In this brochure we will show that circular economy strategies and business models have the potential to create a viable and sustainable plastics value chain. Undoubtably, this brochure cannot cover all aspects of plastics but rather aims on emphasizing most urgent issues and provide inspiration and innovation insights linked to a circular economy for global application. We will give a brief overview of the global industry, look into different types of plastics and their main issues, illustrate the situation today and continue with a deeper dive into the prospects of a circular future. The many Dutch and international best practices and circular frontrunners will illustrate what this future will look like and how plastics can become a smart material. We have identified best practices that inspire and that have the potential to be upscaled and implemented in other parts of the world. We especially hope to appeal to business as a force for good. In the end, businesses are one of the main actors in the plastics value chain and hence, they have the power to make the transition towards a circular and sustainable future. Of course, businesses can't do it all alone. As a circular economy is a system change, we need involvement of all actors. That is why we have included a final chapter with an action perspective for all value chain stakeholders.

By joining forces, Holland Circular Hotspot and TNO have shared insights, networks and resources. We would like to thank the many plastic experts and entrepreneurs we have spoken to and that have enlightened us. We are greatly honoured for the preface by State Secretary for Infrastructure and Water Management Stientje van Veldhoven, Minister for the Environment in the Netherlands. She is a leading global voice for both circular economy and action on plastics. Special thanks to Anne van Bruggen of RIVIM for the textboxes on Micro and Nano plastics and to our guest contributors Merijn Tinga, The Plastic Soup Surfer, Professor Bert Weckhuysen from Utrecht University, Bert Kip, CEO Brightlands Chemelot Campus and Jacob Duer, President and Chief Executive Officer Alliance to End Plastic Waste, who shared their independent visions on the future of plastics.
With this brochure Holland Circular Hotspot and TNO bring their insights to the international level and share best practices with the hope that it will inspire everyone around the world to take action and kickstart circular development.

Please don't hesitate to contact us for further information.

Chapter 2

Plastics today

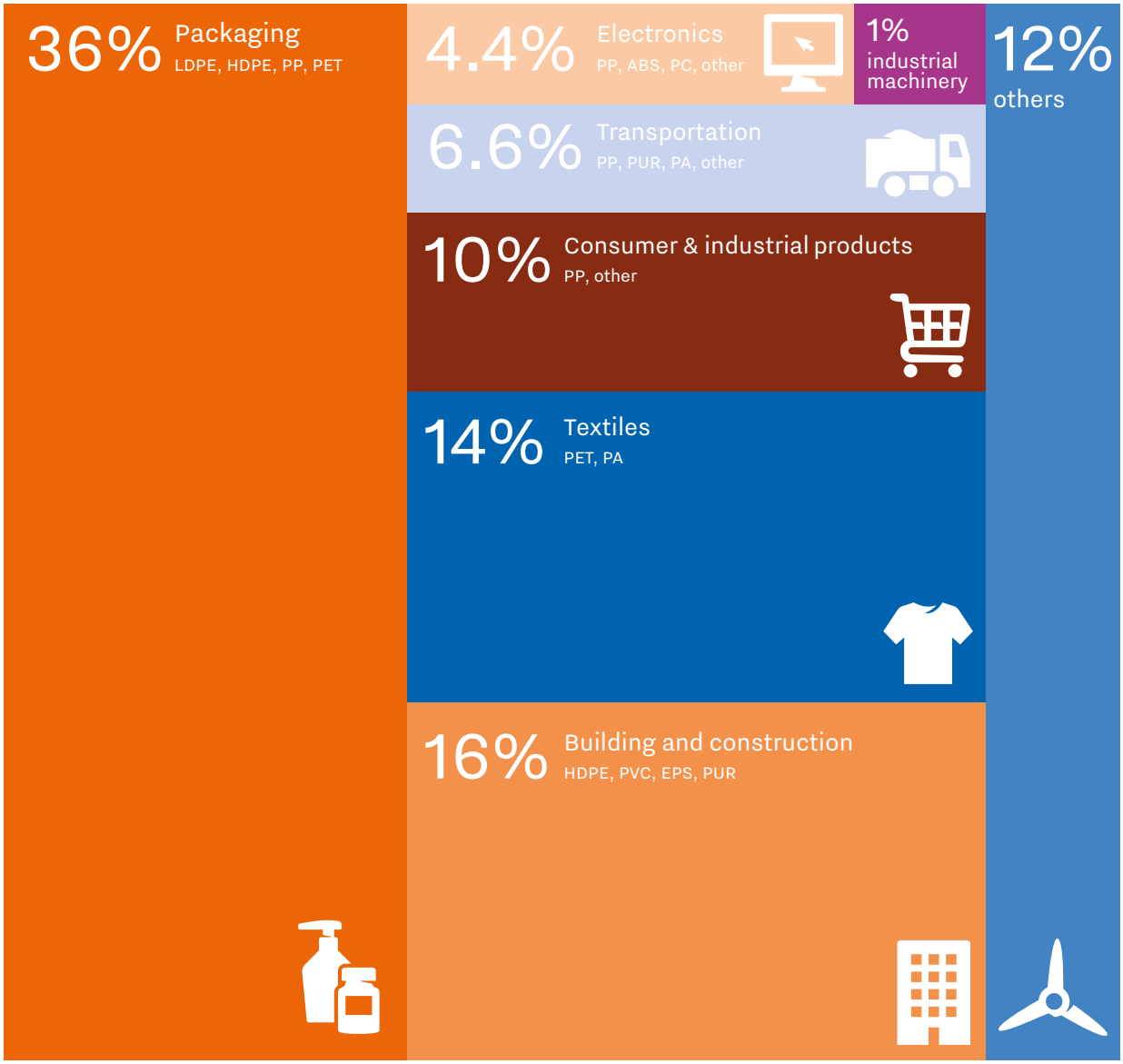
What is plastic

It's not too much of a stretch to say that plastic made the modern world possible. Many things that we take for granted today depend on it. Plastic has many benefits in application; due to its versatility it serves as a crucial component across all sectors. Plastic is light weight, which saves CO2 emissions, it contributes to food waste prevention and food safety and another crucial point: it is affordable. For these reasons, few environmentalists seriously talk about turning back the clock to a pre-plastic age. The challenge is how to manage the worst effects of its proliferation and gain control of plastic waste and the pollution it causes.

Plastic comes in various forms and qualities. Today's main feedstock for producing different plastics is virgin crude oil. The most commonly utilised plastics are: 51% PE (HDPE & LDPE), 21% PP, 15% PET, 5% PVC, 4% PS, 4% Others.

Plastic Distribution over Sectors

Source: Plastics Europe: Plastics- The Facts (2020), Our World in Data: Plastic Pollution (2018)



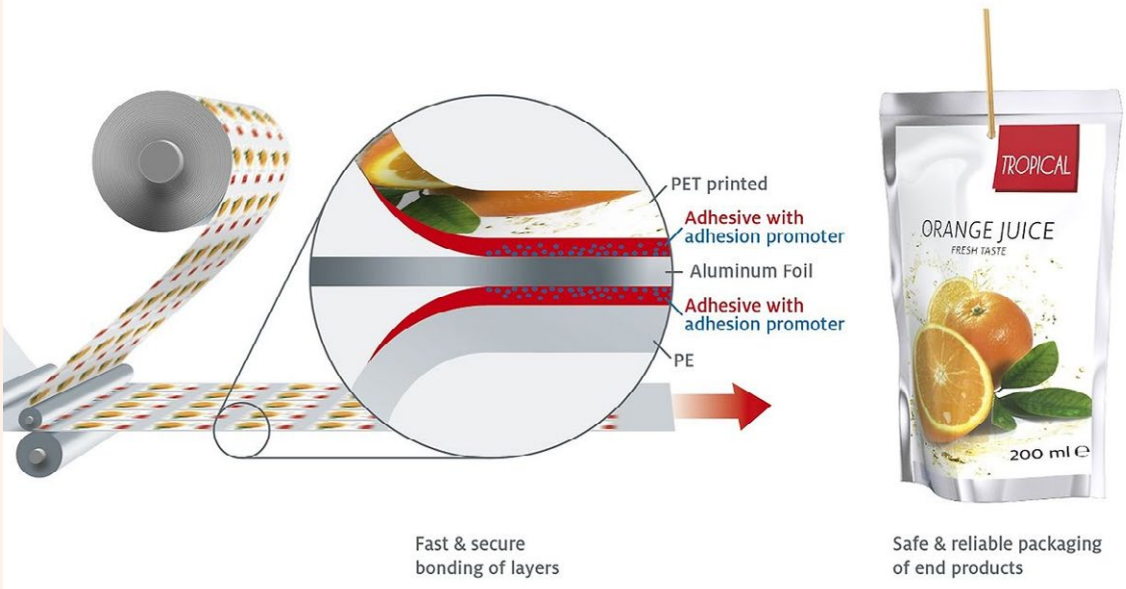
Plastic production

Plastic production has almost 200-fold itself since 1950: The world´s annual production of plastic is to date 360 million metric tonnes.[1] To put things in perspective: The plastic issue we are confronted with today and which is posing a major threat to our biosphere now, was only established within the last 70 years. As demand for plastics will accelerate due to the growth in world population and wealth combined with a growing demand for use in, for instance, packaging, buildings and the automotive industry, plastic production is estimated to double within the next 20 years, which means an annual production of almost 700 million metric tons.[2]
More than half of the volume of polymers is produced in Asia, of which 30% in China, followed by North America (18%) and Europe (17%).

COMPLEX PLASTIC PRODUCTS

During the design of plastic products, often complex products are made to specify characteristics of the plastic product needed for its future purpose. Plastic products are made complex by combining polymers with a large variety of different types of additives, all for different purposes (additive table reference). Furthermore, plastic polymers can be used in a mix to obtain specific properties. Another complexity dimension is added by adhering plastics to other materials, such as in electronic equipment, where the plastics cannot be separated easily from the rest of the product which makes both remanufacturing of the product and recycling of the used materials challenging.
These complex products result in a lot of challenges for recycling. Most of today´s collection-, sorting- and recycling facilities are not able to process mixed materials, as these can often not be separated from one another when processed in the same product. For these products, the only end-of-life is either incineration or landfill. Examples are multilayer designs for packaging where different polymer types are connected to extent shelf life to decrease food waste. Another example is plastics used in cars, for the aviation sector or in wind-mill blades, where to lighten materials and to be energy efficient, plastics are reinforced with glass fibre instead of steel.

Source: *Legislation on GLYMO will shape packaging in 2020 (henkel.com)*



Fast & secure bonding of layers

Safe & reliable packaging of end products

Why linear supply chains are doomed to fail

Plastic & where it goes

Because current plastic supply chains are far from circular, we are faced with the task of dealing with an immense volume of discarded plastic. From all the plastic that has been produced since 1950 only 1,7 percent has been effectively recycled (plastic which has been reintegrated back into production). [3]

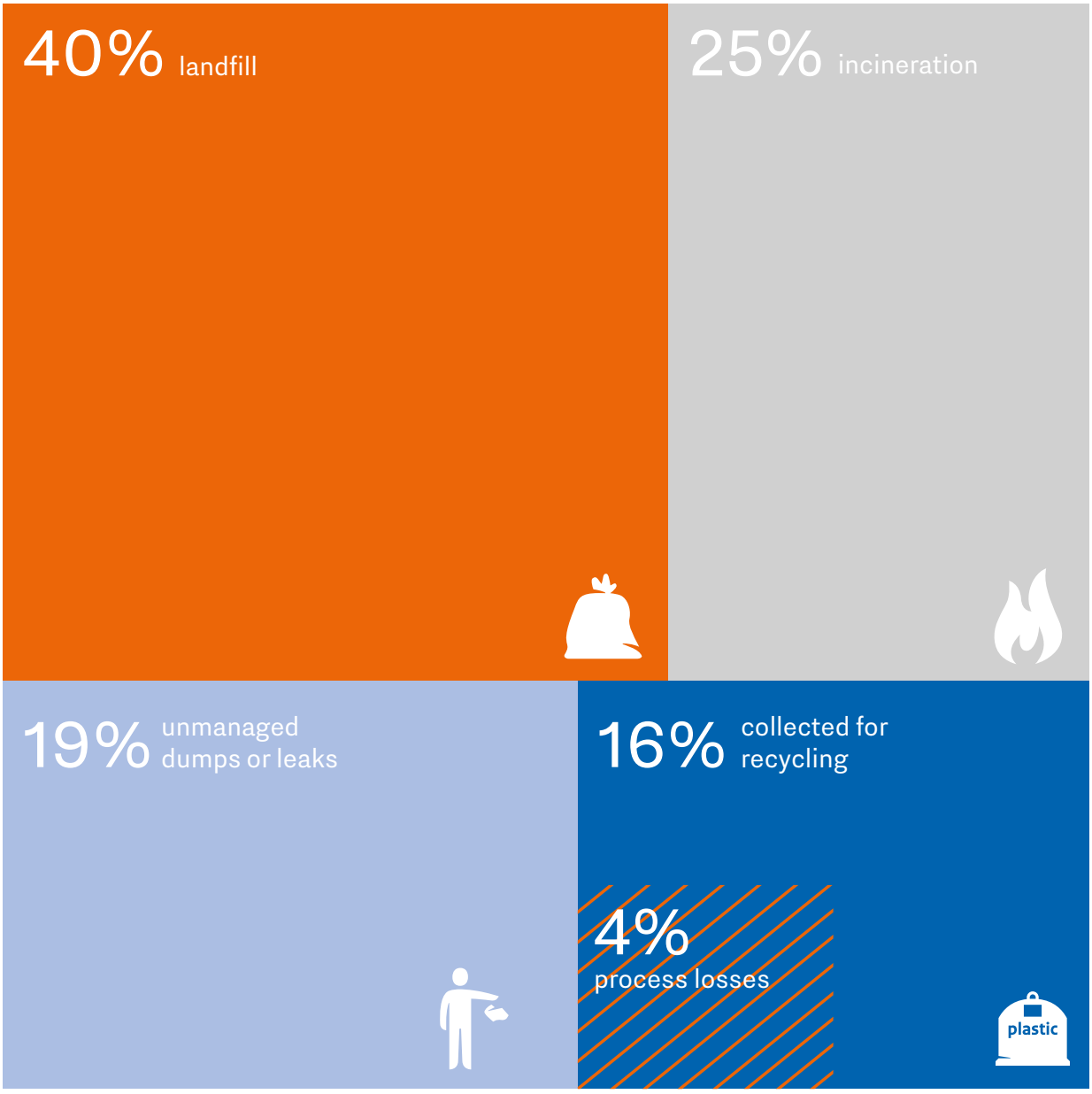
Depending on the product, the life-cycle of plastic can look very different and with that the lifespan varies.

Single-use plastics

Single-use plastics, mainly for household and packaging purposes, have a very short life cycle and come in immense volumes. Because of accelerating waste production in combination with lacking recycling opportunities, material with a value from over 110 billion US Dollars is thrown away with the disposal of plastics every year. On top, further costs of 40 billion US Dollar are estimated to arise from diminishing ecosystem services, damaging infrastructure and arising GHG emissions. Confusingly those costs outperform the profits from the packaging industry itself. [4]

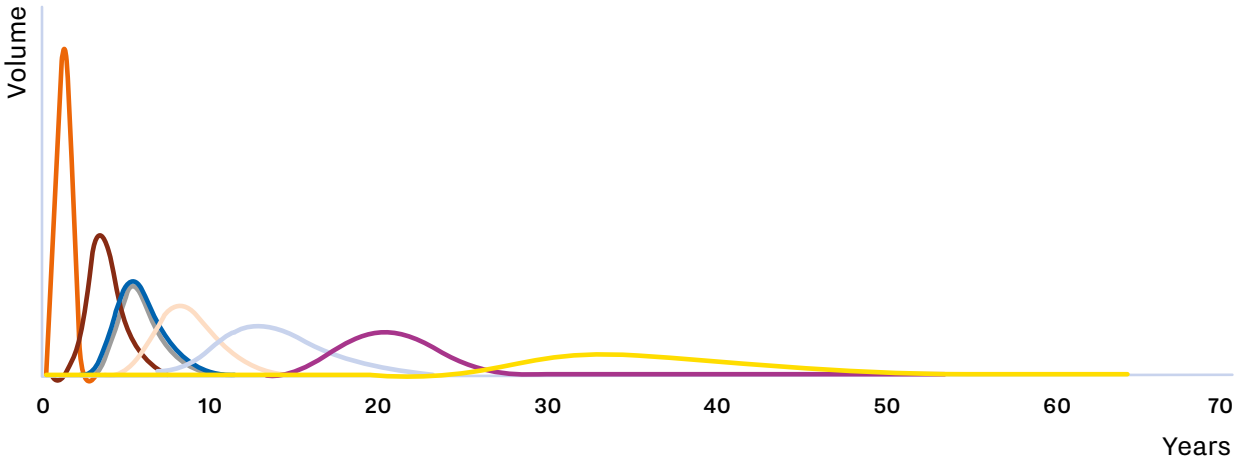
Global fate of plastics

Source: McKinsey & Company, global polymer flows



Product lifetime distribution & annual plastic waste generation by sector

Source: Science Advanced: Production, use, and fate of all plastics ever made (2017), Our World in Data: Plastic Pollution (2018)



46.7% Packaging

14% Textiles

12.6% Others

12.2% Consumer & institutional products

5.6% Transportation

4.3% Building & construction

4.3% Electrical/ electronic

0.3% Industrial machinery

Each sector faces different challenges with plastic waste emerging on the end-of-product life-cycles. Due to short life-cycles, the sectors of packaging, textiles and consumer goods appear to be the most pollutant when looking at emerging quantity of plastic waste.[1] However, here the opportunity of circular design rises to tackle the problem expeditiously. Annual pollution of the transportation, building and construction sector is comparatively, notably lower, because plastic is locked in products over years. This, on the other hand, means that we (will) have to deal with product design from decades ago.

Plastic pollution

The increase and consistent demand for plastics and plastic products are responsible for continuous increase in the production of plastics, generation of plastic waste and the harm it has on the environment. This includes both large plastics (macro plastics) and smaller fragments (micro and Nano plastics). Because plastic is a persistent, inert material that degrades very slowly, it can cause environmental damage over multiple decades. It impacts the functioning of ecosystem services (ESS) clogging rivers, contaminating groundwater and interfering with animal food systems. These occurring damages are referred to as environmental hidden costs. True pricing is a tool to calculate the real price plastic needs to have when the costs to preserve or to restore damages of ESS is included.

Microplastics in a circular economy

A circular plastics strategy also needs to take into account that plastic wears and breaks down, which can lead to the formation of microplastics that leak into the environment. Microplastics are small solid plastic particles (smaller than 5 millimetres), poorly soluble in water and non-biodegradable. They can pose negative direct and indirect threats to the environment when they enter water ways, air, soil or the food chain. And to human health as they enter the air we breathe, water we drink and foods we eat (SAPEA). The risks for humans and the ecosystems are largely unknown, but knowledge institutes are studying the possible effects of microplastics in water, air and soil and strong indications emerge that ecosystems and human health is under threat. Policymakers realize that we cannot afford to wait until all the gaps in our knowledge are filled before taking measures to reduce its emission. Preferably, emission is prevented at the source and a tier-based approach can be applied while focusing first on the greatest sources, which include break down of plastic waste in the environment, wear from textile fibers, tires, agricultural plastics and paints.[5] Collaboration across the value chain is required to reduce emissions effectively such as occurs in the microplastics textiles network. Here RIVM supports, alongside TNO, the stakeholders in defining appropriate measures. This newsletter contains the latest in knowledge and policy developments.

The first challenge of preventing the negative impact of plastic waste on the environment is by ensuring sustainability in the use, consumption, and waste generation of plastics. This means improving waste management infrastructure, circular purchasing and using recycled plastics. A major challenge; especially for countries which don't have the financial resources to put sufficient waste infrastructures in place.
Plastic waste is often mismanaged and can enter the environment through either **inadequate disposal** or **littering**. **Inadequate** disposal occurs when there is a waste collection in place, but the collected waste is handled inefficiently, or unsafely. **Littering** describes the disposal and discharge of waste directly into nature due to the lack of a sustainable waste management infrastructure or irresponsible handling by individuals or industries. Today, 55% of waste is discarded into mismanaged landfills; almost 40% of global plastic waste leaks into the environment polluting waters, air and soils.[6]

Plastics and the SDGs

The issue of plastic pollution is linked to a number of Sustainable Development Goals (SDGs) as it causes severe implications on multiple levels: threat to marine- and wild life, threat to ecosystems, and threat to public health. This brochure directly addresses those issues by focusing on SDG number 12: responsible consumption and production in order to address the linked topics: SDG 3: Good health and well-being, SDG 6: Clean water and sanitation, SDG 11: Sustainable cities and communities, SDG 13: Climate action, SDG 14: Life below water (protection of the seas and oceans), SDG 15: Life on land (restore ecosystems and preserve diversity).[7]

Photographer: Freek van Eijk

Chapter 3

A future and circular vision on plastics

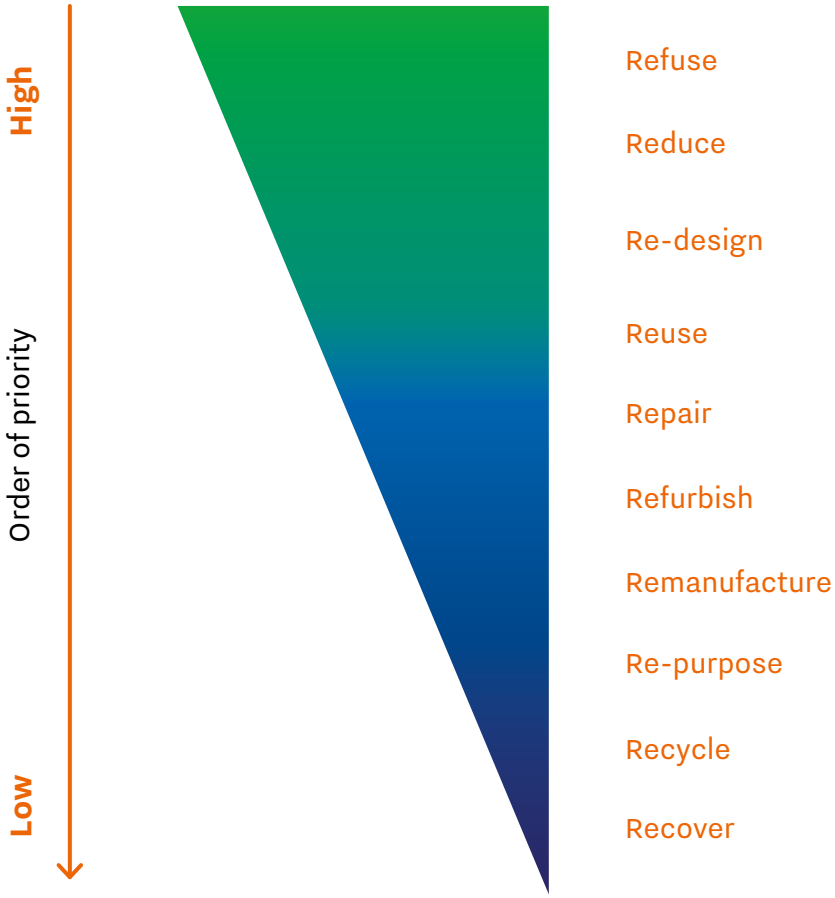
Defining a circular economy

In response to the global challenges of the 21st Century, the circular economy has emerged as the alternative to the unsustainable linear (take-make-waste) economy. The linear economy results in a double burden for the natural system; extraction of resources and disposal, pollutants and emissions from waste. In a circular economy, materials or products are not destroyed or disposed through waste, but the value is retained on various levels, and kept in a closed loop within the economic system. Less virgin resources from the natural system are required (take), and less emissions and pollution occur through disposal (waste). In a circular economy, also the use of renewable energy sources and materials are key. Renewable energy and materials are those that can be replenished within the human lifetime, opposed to non-renewables, which can only be replenished after millions of years.

For materials to function in a circular economy, the 10 R-hierarchy of circularity[1] can be applied. The R strategies correspond to different levels of value retention of the products. Generally, the more value retention can be kept, the higher circularity and reduction of pressure on the environment. The first R's (refuse and reduce) are highest on the value hill, although attention should be paid on whether alternatives actually result in lower impact on the environment and resources. Descending the value hill, the R strategies focus on design of products for circularity. Last in line, in the R strategies focus on material and resource recycling. However, due to the laws of physics, such as degradation, breakdown or quality reduction, a fraction even gets lost in a fully circular system. The R strategies focus on the post-use phase and require most attention in the transition towards a circular economy, as we inherit the products and materials of the linear economy. In order to apply

Levels of circularity: 10 R hierarchy

Source: J. Cramer



the R strategies, we need new business models and innovative product design.

Why plastics in a CE?

The circular economy will play an important role in shifting the global debate on plastics, mobilising a systemic shift towards a common vision for circular economy for plastic, with industry commitments, government policies, and increased public awareness. Due to its unique and beneficial properties, **we want to be able to use plastics within the circular economy**.

Plastics can serve the circular economy in various manners, including efficient generation of renewable energy (like windmills), reducing CO_2 emissions during transportation of products as less weight needs to be moved, or even emission reduction in cars, trains and planes themselves.

However, there are some fundamental changes required before plastics can be considered a material suitable for the circular economy. A Circular Economy calls for a profound transformation in the way we work and produce, and the way we design, teach, invest, and buy. The next chapter moves through the plastics life cycle from a linear perspective; from the start (feedstock) to end (waste) and discusses which fundamental adaptations are required. However, as the circular economy is a circular system, changes can start at multiple stages throughout the lifecycle.

Niaga® click-unclick adhesive granules

Chapter 4

CE applied to the plastic value chain

Throughout its life cycle, plastics follow various sets of activities where value is added to the plastic until it is delivered to market. After use, plastics are collected for the end of life. All these steps together form the plastic value chain. The value chain infographic below shows the state-of-art, all activities from raw material to the end-of-life of plastics in a linear value chain. In blue, circular strategies are visualized. All steps are accompanied by best practices throughout the chapter and main opportunities and challenges of the plastic value chain within the circular economy are discussed.

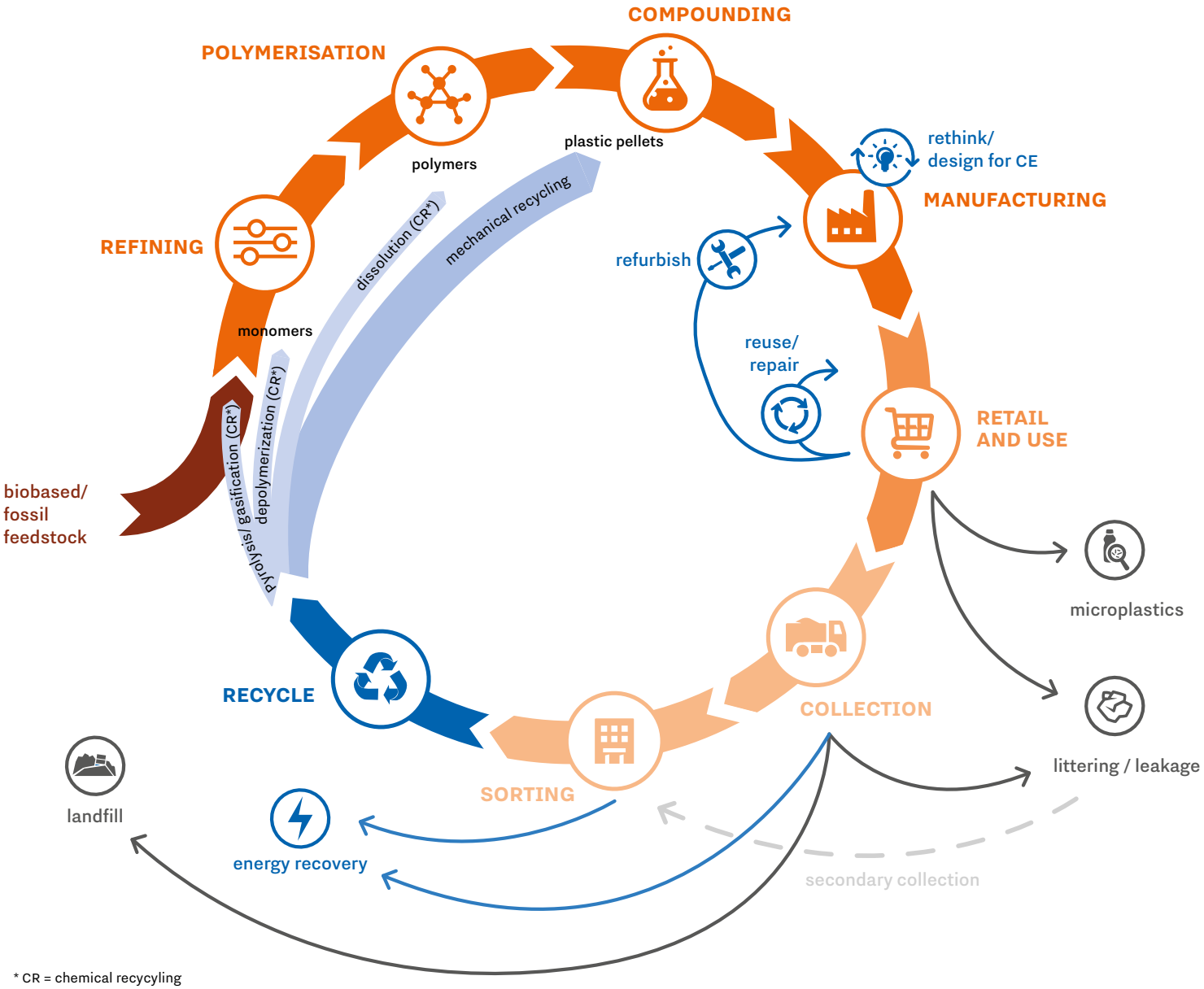
The Great Bubble Barrier has developed a technology which can intercept plastic pollution in rivers before it reaches the ocean: the Bubble Barrier, a bubble curtain with a catchment system. The system of the Bubble Barrier is fish-friendly, does not hinder ship traffic, and covers the entire width and depth of the waterway. After several pilots, the first long-term Bubble Barrier in the world was placed in November 2019 in Amsterdam.
The Bubble Barriers serves more than only a technical solution. To solve the problem of plastic pollution we need systematic change, and the Bubble Barrier will be a crucial tool to collect monitoring data about the plastic pollution in our rivers in order to help shape new policies. Each new Bubble Barrier is an important step in the worldwide fight against plastic pollution.

Secondary collection

The Ocean Cleanup has developed an autonomous device, "The Interceptor™" which relies on natural forces to capture plastic in the world's most polluting rivers, preventing this plastic from entering the ocean in the first place. The solar powered Interceptor™ functions as a mobile waste collector, which can collect up to 50.000 kg of debris from the water daily. When it reaches capacity, the system sends a signal to local operators to come and collect the waste.

Secondary collection

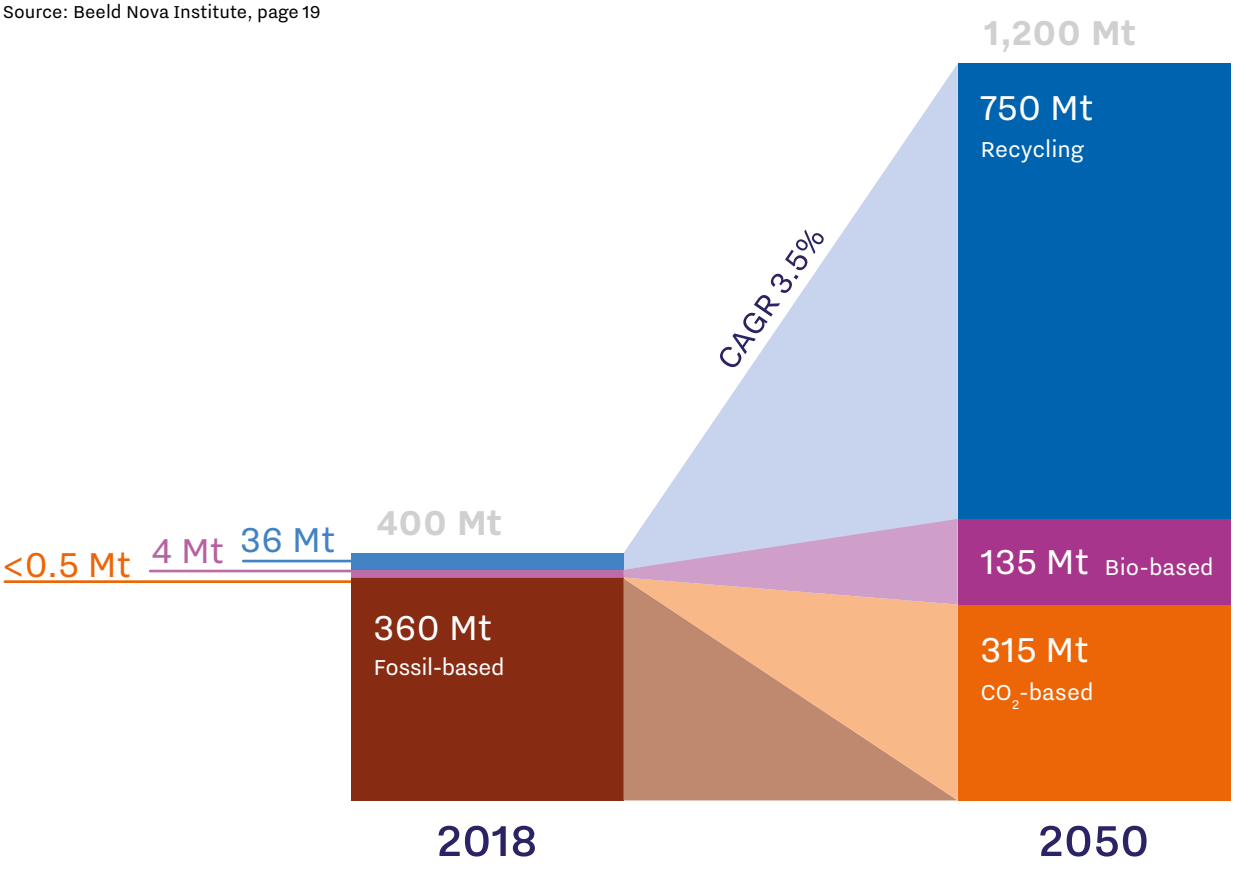
Value chain of plastics



* CR = chemical recycling

World Plastic Production and Carbon Feedstock in 2018 and Scenario for 2050 (in Million Tones)

Source: Beeld Nova Institute, page 19



Biobased plastics

Most biobased materials are used for producing biobased plastics. Today, biobased plastics are used in various sectors, but mainly used as packaging material.
Biobased resources can have a broad origin and the environmental impact can vary accordingly. To assure biobased plastics don't compete with food production or cause negative environmental impacts, residual material and non-edible by-products from agriculture can provide raw material for plastic value chains.
The most commonly used biobased plastics at this moment are:

3. PLA (polylactic acid) based on corn or sugar canes
4. Starch based plastics based on (waste streams of) potatoes, corn, cassava
5. Cellulose based plastics based on wood pulp
6. Bio-PE (biobased polyethylene) based on sugar canes or paper-industry waste streams

Standards, auditing programs and certification schemes can be used to ensure biobased plastics are sustainable, i.e. ISCC PLUS, Bonsucro and Better Biomass.

Biodegradable plastics

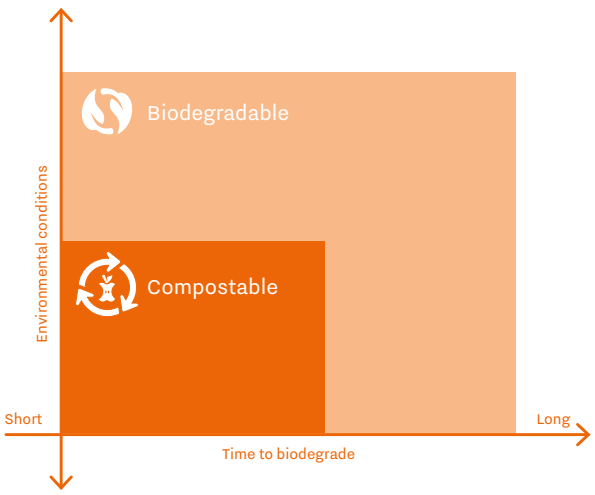
It must be noted that biobased plastics are not the same as biodegradable plastics. A material is biodegradable when it can be decomposed by microorganisms in soil or aquatic environments.
Materials are compostable when the material can biodegrade in industrial composting facilities (like PLA).

Some biobased plastics are neither biodegradable nor compostable (like bio-PE). Confusion can arise when using the term biodegradable – using terms like 'industrially compostable' can reduce confusion.

In short: **Not all bioplastics are biodegradable or compostable, and not all biodegradable or compostable plastics are biobased.**

Biodegradability

Source: A. Gendell (2018)



Challenges
The sustainability advantage of a shift from fossil based to biobased plastic is under ongoing discussion, as well as in what sectors bioplastics are best applied. The ambiguity about recycling capabilities of bioplastics has caused bio plastics to be viewed critically as there is a worry it will disturb existing plastic sorting- and recycling routes.

Opportunities
Biobased plastics has potential in a circular economy. For example, China sees biodegradable green packaging as a solution to packaging waste in the courier sector: In its Guidance from 2017, China stipulates a 50% quota of degradable green packaging by 2020. Considering China's preeminent position as the factory and thus the packager of the world. Its decision towards bio packaging will certainly impact other countries waste management systems.

Refining, Compounding - From oil to plastic polymers

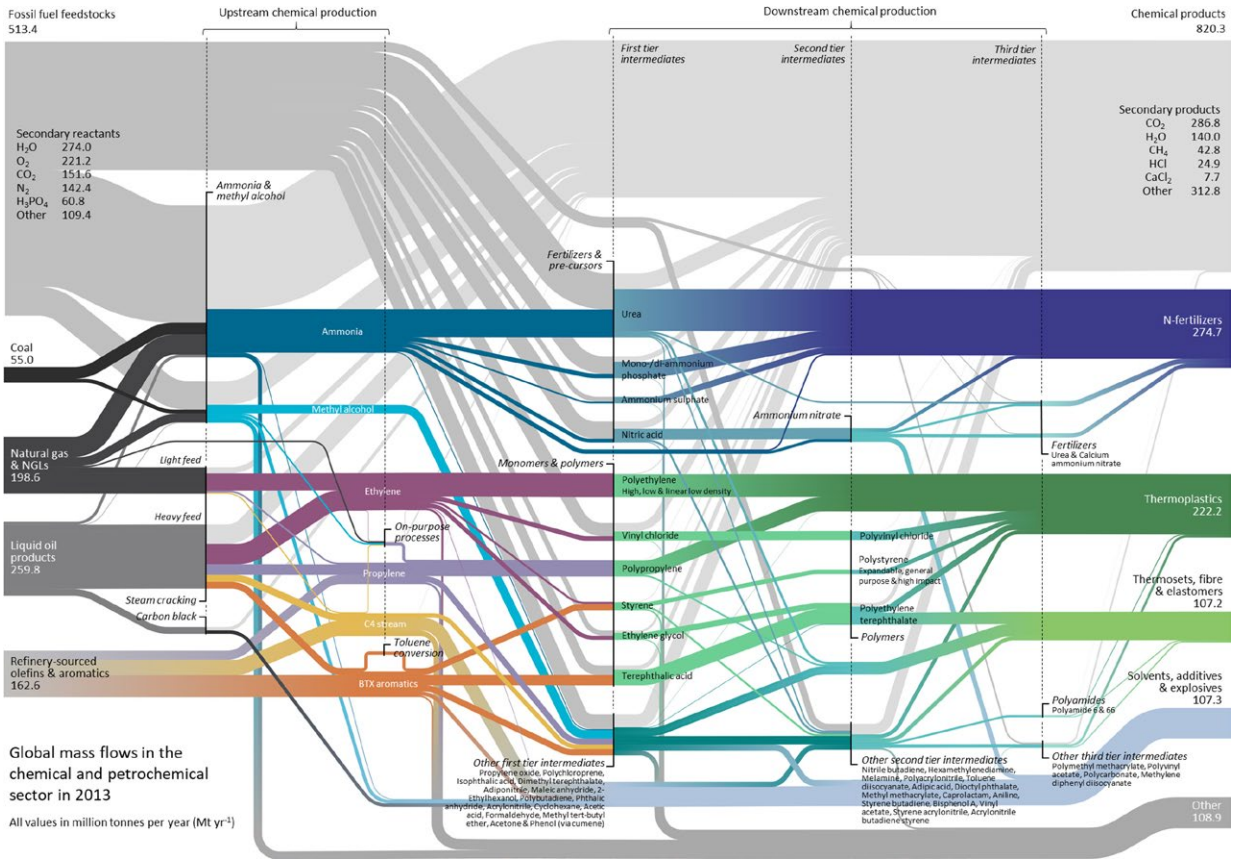
The refining process starts with the **steam cracker** that breaks down the plastic feedstock (naphtha and natural gas). Naphtha is the name of the fraction with medium weight carbons (C5-C12) which is separated from crude oil during refinery. The cracker transforms naphtha into various products, which include the olefin gases; the building blocks for most used (commodity) plastics such as PVC, PE and PP. Additionally, the cracker product stream is processed to form so-called aromatic hydrocarbons. This process is known as **catalytic reforming**. These compounds are the chemical building blocks to produce more 'complicated' plastics; including PET, PS and PC.

Manufacturing

When polymers or plastics are produced, they generally first are shaped into pre-production pellets. These pellets are used for manufacturing plastic formulations according to the design. In this step, the required additives including colour, plasticizers, filler, reinforcements and fire retardants are added to the product. Some plastic products consist of close to 100% polymer, while other products only contain no more than 30% polymer, while the rest is made up of reinforcement (like glass fibres) in windmill blades. For manufacturing various processes are used to shape products, such as injection moulding, blow moulding and thermoforming.

Sustainable chemicals in circular plastics
To ensure a safe and sustainable transition to circularity as well as a pollutant free environment, the presence of hazardous substances (additives) in (bio) plastics should be minimal and risks negligible (Chemical Strategy). Additives are added for various

Source: https://pubs.acs.org/doi/10.1021/acs.est.7b04573



functions like malleability or UV-protection, but can pose risks to the environment and human health. In a circular economy, plastics are recycled and reused on a large scale which could cause new risks.[8] A safe circular economy requires sharing information on substances used across the chain, enabling safe-by-design strategies, and ensuring responsible use of substances and materials in products when safer alternatives are not available.[9] The sharing of information is currently a major challenge. Ultimately, hazardous substances in a circular economy should only be used in (plastic) products when alternatives are unavailable and their use is considered essential for the functioning of society, and risks are controlled to safeguard our environment and health.

Design (Rethink, refuse, re-use)

Today, design of products mostly focuses on the use-phase of products. This is fatal for circular economy, mainly as products are not designed for re-use and recycling. It is therefore crucial for the design phase to enable circularity of a product by taking into account R strategies.

Challenges

- Today, freedom of design, where all materials can be used and with main focus on functionality during the use phase, is one of the main problems for the circular economy. Complex design for the use phase often makes the R strategies complicated to implement, including re-use and recycling, hence leading to waste production that could be avoided.
- Designs for R strategies can also conflict each other. For re-use, one can address the use phase of the product; what additive can I use to increase lifespan of my product and prepare it for re-use? However, this specific additive can increase the lifespan but results in recycling problems, the use of such additives should be avoided and alternatives considered.

Opportunities

- Design for the full life time of the product, including end-of-life.
- For long live plastic product design strategies aimed at life-time extension (repair, refurbishment, remanufacturing) make sense.
- For short live plastics products like packaging material choice and design for reuse and recycling make sense. Re-use is especially an interesting concept to fight single-use waste. As an example, supermarkets create filling stations where consumer can fill their brought in containers which can be used as packaging all over again. It is important to rethink and redesign single use plastic where possible.

CIRCO has developed a unique yet simple method that is inspiring, activating and that supports creatives and professionals within the plastic and packaging industry to create circular business.
The method enables entrepreneurs and industry professionals to identify business opportunities and use circular design strategies to redesign their own propositions, products/packaging, services and business models. Supported by various cases, expert input and value chain interaction, participants leave with a concrete implementation roadmap. Research shows: 66% of the participants have implemented their new circular propositions!

CIRCO

Design

Chemelot is Europe's first large scale, multi-stakeholder circular chemical industry hub.
Key elements are

- The Chemelot Industrial Park as epicenter of the circular chemical industry,
- Brightlands Chemelot Campus as hotspot for circular innovations,
- Human Capital Agenda as vehicle that captivates and trains talent at all levels,
- Circular Society as enabler towards a healthy living environment.

Amongst others, Chemelot invests in the transition from linear to circular by converting both the energy source and raw material input from natural gas and naphta to green electricity, plastic waste and biomass.
For this very large scale multistakeholder setting an unique Value Case Methodology has been developed. It incorporates business models design and is combined with a networked approach reflecting the physical production and the partners strategic perspectives. This leads performance indicator and a validation round and finally triggers collective action.

chemelot
for today's future

Rethink

Collection and sorting

The collection of waste, including plastics, varies strongly per country, region or even per product type, and hence changes on all scales are required. In countries with adequate waste management, collection and sorting are in place. This are generally countries with governments driven by regulation and enforcement. Collection can take place door to door or by a bring facility like a municipal environmental station where the waste can be disposed in different fractions.

Potential of the informal sector

In many countries, there is in parallel to regulated collection, a large informal sector that 'waste pick' the valuable materials from the street or dumpsites, such as PET bottles. The informal sector is often more efficient than we think but only focusses on materials that have value. However, hygiene and social conditions are generally poor. Further professionalization is needed as well as regulatory development to ensure that non-valuable and environmentally damaging flows, like single use packaging, are collected as well.

Modulo-Milieustraten offers smart collection solutions with affordable and easy to install drop-off facility for waste separation which functions as a base for next recycling steps which aims to reduce illegal dumping and littering. The concept is simple: a drive through offers multiple discard containers for different waste types. The installation allows flexibility (extension of installation) and application on different locations as it constructs quickly. Modulo offers the customers a Refund Guarantee and a Re-use-pool for the modular elements to support the Circular Economy. The Dutch drop-off innovation has already been implemented in the Benelux, Germany and the Nordics States. For more information, get in contact.

Modulo MILIEUSTRATEN
ADVIES | SERVICES | REALISATIE

Collection

When collected, plastic waste is often mixed with different types of plastics and with other materials. Sometimes, plastics are collected separately; such as bottles, or as plastics-only waste streams. The task for sorting facilities is to create a clean, mono-plastic or dedicated (for downstream processing or other market-reintroduction activities) waste streams from different levels of collected waste. Next to manual sorting, there are technology examples that are used like drums, ballistic separators, wind sifters, near infrared separators density sorting using saltwater baths or even magnetic fluids. Sorting can be done to extract a large fraction of valuables destined for example for mechanical recycling (positive sorting) or can be done to extract a small fraction of process disturbing elements like for example PVC (negative sorting) to produce high quality feedstock for thermochemical recycling.

PETCO is the trading name of the PET Recycling Company NPC South Africa. PETCO, as a Producer Responsibility Organisation (PRO) financially supports, on behalf of its members, activities along the waste PET value chain, fulfils the PET industry's role of Extended Producer Responsibility (EPR), a voluntary industry, and the vehicle through which the PET industry self-regulates and co-ordinates its recycling activities. By imposing accountability over the entire life cycle of PET products and packaging, companies that manufacture, import and/or sell PET products and packaging are financially and physically responsible for such products after their useful life. PETCO members include brand owners, resin producers, converters, and bottlers.

petco
PET plastic recycling south africa

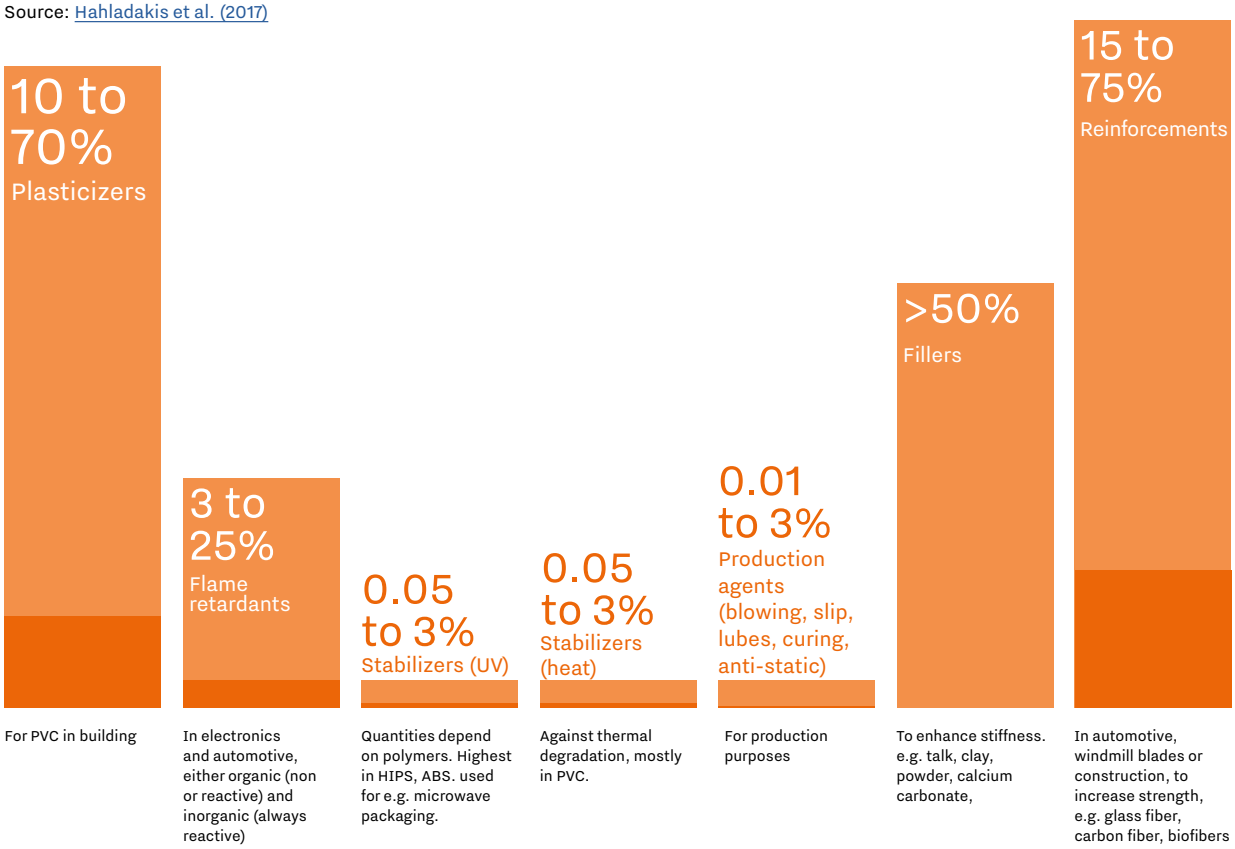
Collection

SweepSmart provides turn-key Smart Waste Centres for waste collection and sorting in upcoming economies, by reinventing European technology to align with on-ground reality of lower waste management budgets, logistical challenges and inclusion of the informal sector in these countries. They can work from consulting and design until implementation and long-term service, supported by a full package of equipment, IT solutions and training.

Sorting

The challenge of additives for circular plastics

Source: Hahladakis et al. (2017)



Van Werven Plastic Recycling specialises in creating high-quality raw materials from post-consumer rigid plastics. Those are collected from construction waste, industrial waste and municipal recycling centres. Incoming waste runs through a procedure of manually sorting, shredding, washing and lab-analysis for testing of material to become re-manufactured into high-quality products. Operating without any subsidies, Van Werven relies on cooperation with other stakeholders in the chain: a fundamental asset for circular economy models. Today their seven facilities are placed in The Netherlands, Belgium, Ireland, the United Kingdom, Sweden and Poland. By closing the chain and re-using raw materials, Van Werven Plastic Recycling has taken an important step towards joint sustainable development.

Sorting

SUEZ Shows best high-tech and fully automated sorting practice on its sorting center sight in Rotterdam which focuses on plastic packaging including cartons and metal packaging. This plant manages to sort around 1/3 of all plastic packaging waste in the Netherlands. In the center PET bottles and trays, HDPE, LDPE and PP plastics are sorted out of the input waste and pressed into cubes to be sent to recycling companies. In the Plastic Sorting Center also tours are offered to experience waste management in close proximity.

Photographer: Bas van Spankeren

Sorting

Recycling

Mechanical (physical) recycling

After sorting of plastic to polymers, the sorted fractions are further cleaned, shredded, molten and re-compounded to pellets. Pellets can be used in the manufacturing phase to make new products. This is the process of mechanical recycling.

Chemical recycling

Chemical recycling is a term for a set of emerging innovative technologies that turn plastic waste into base chemicals, monomers and feedstocks.
Chemical recycling provides additional options and should be seen complementary to mechanical recycling. It bridges the world of waste management and the petrochemical industry. The time to develop mature technological readiness levels can be between five to ten years for these technologies.
McKinsey & Company has predicted that chemical recycling will contribute to a 60 billion USD growth in the profit pool of the petrochemical and plastics sectors between 2016 and 2030. [10]

In TNO's Circular Plastics publication (2020) chemical recycling will in 2050 have outgrown mechanical recycling several times.[11]

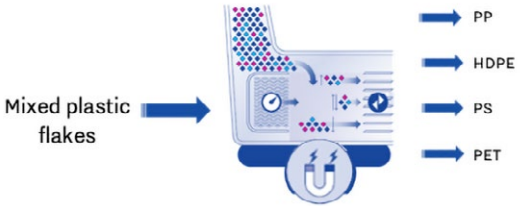
QCP BV, located in Limburg, The Netherlands, utilizes household packaging waste to transform into HDPE and PP compounds. QCP is a relevant showcase for best collaboration along the value chain: QCP has formed strategic relationships with SUEZ for feedstock input (sorted waste) and LyondellBasell who markets the QCP products under their brand names Hostalen and Moplen.

Photographer: Ermindo Amino

QCP
QUALITY CIRCULAR POLYMERS

Mechanical recycling

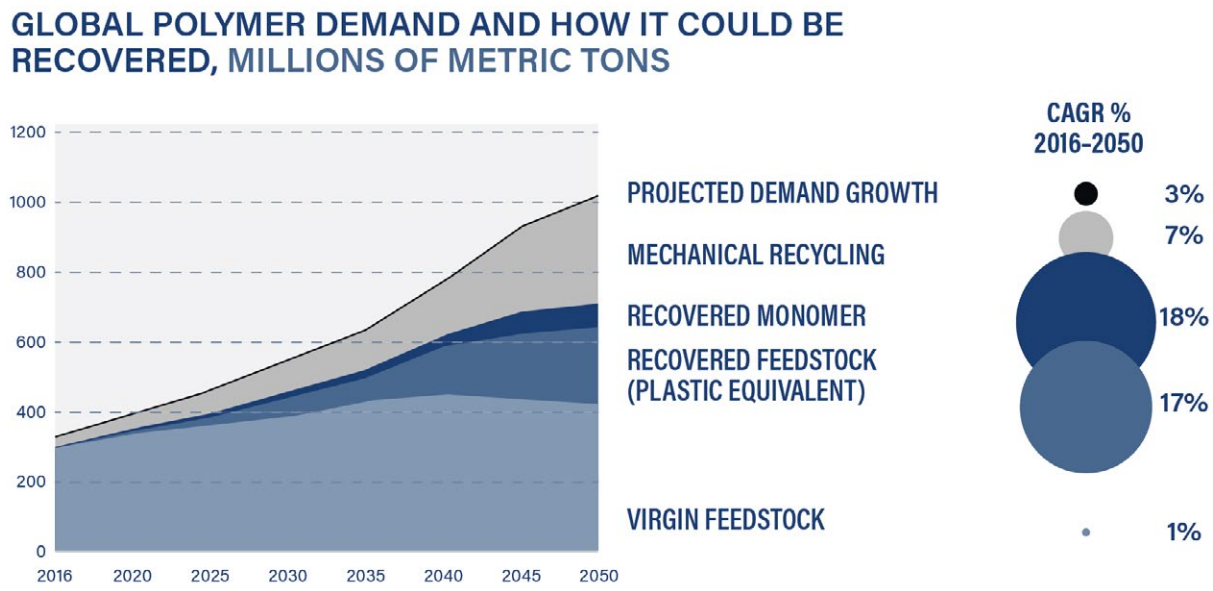
Umincorp offers Magnetic Density Separation (MDS) technology to economically recycle mixed rigid plastic packaging waste back into 99% pure polymers. The Umincorp process enables a circular plastic packaging-to-packaging supply chain at 80% lower CO2 emissions than conventional technologies. Together with Umincorp, the cities of Amsterdam and Rotterdam already recycle 25.000 tons of rigid plastic waste per year.



Umincorp

Mechanical recycling

Source: How plastics waste recycling could transform the chemical industry. December 2018, McKinsey on chemicals



Depolymerization

One type of chemical recycling technology is **depolymerization**, also referred to as monomer recycling. This technology breaks down the polymer to their respective monomers. Consequently, the monomers can be built up again in new "virgin quality" polymers. Such an approach is feasible for polyesters (notably PET) and polyamides. Various depolymerization technologies are based on solvolysis, where chemicals are used for polymer breakdown; e.g. glycolysis (with ethylene glycol, for PET, PA), methanolysis (with methanol, for PET), hydrolysis (with water, potentially for PC), ethanolysis (with ethanol, for PS).

Ioniqa Uses depolymerisation to convert coloured shredded PET material (food and non-food packaging and polyester fibres) back into a pure, high-quality raw material for PET which can again be used for packaging purposes such as bottles. With that they have established a solution towards a closed loop for PET in which material doesn't lose value and can be reused infinitely while saving up to 75% CO2. In 2019, Ioniqa received the `National Icons´ award from the Dutch Government and is a promising innovation to be scaled up around the world based on its 10k ton industrial plant in the Netherlands.

Depolymerisation

CuRe wants to rejuvenate any type of used polyester (i.e. packaging, textiles) which cannot be treated with mechanical recycling, by removing color and contaminates and converting it into clear pellets with the same properties as virgin grade polyester. This makes polyester a fully circular material.

Depolymerisation

Plastic Energy uses innovative chemical recycling technology to process end-of-life plastics that are difficult or unable to be mechanically recycled. Plastic waste is turned into recycled oils, called TACOIL, which can be used in the manufacturing of virgin-quality food-grade plastic products, which contributes to a more circular economy. This global company is headquartered in London, and has two operational recycling plants in Spain, with plans to construct multiple plants in Europe, including one with SABIC in the Netherlands.

Pyrolysis

Enerkem turns mixed plastic waste into methanol and ethanol which can be used for solvent and coatings. Enerkem is also working with plastic producer Nova Chemicals to convert waste directly into olefins like ethylene and propylene. In the Enerkem carbon recycling technology, through a thermochemical gasification process, carbon is converted into products rather than emitted as CO2. Shredded mixed plastic waste is transformed into ultra-clean syngas which can be used for biofuel or other chemical products.

Gasification

Thermochemical recycling

Another chemical recycling technology that is suitable for mixed input is thermochemical recycling. Through applying heat and limited or no oxygen, polymer chains are broken down to chemical building blocks, generally so-called pyrolysis oil, similar to naphtha), short olefins like ethylene and propylene or syngas (CO + H2). Two example technologies are gasification and pyrolysis. The hydrocarbon mix can replace feedstock, such as naphtha or natural gas, to make new plastics or used in other chemical processes. The pyrolysis oil (hydrocarbon mix) can also be used to replace fuels like diesel or kerosine. The fuel route is considered less circular as it only creates one additional life cycle. Whereas the route via chemical building blocks for new materials is a potential multicycle one. For example, the Dutch government only counts chemical recycling for chemical building block as recycling and considers chemical recycling for fuel as valorisation.
Thermochemical recycling is energy intensive but in general terms the footprint is often better than incineration.

Gasification forms synthesis gas (CO + H2). This can be seen as incineration in the presence of a low amount of oxygen. This technology has – in a circular perspective – a lower priority than pyrolysis as the product gas consists of much smaller molecules, thus less valuable. On the other hand, this technology can cope with lower quality mixed feedstocks.

What recycling method is best?

In the future, there is likely a large number of different recycling options available. When multiple options are available, the optimal recycling technology has to be determined for existing and future waste streams and the types of polymers available. The existing waste hierarchy should not be applied blindly. In order to determine what recycling technology is the best choice, other important factors play a role here as well:

- The costs of the recycling technology
- The environmental impact of technology
- The environmental footprint of the plastic/ additives
- The quantity of the plastic waste input
- Health and safety aspects of recycling technology
- Quality of output
- Quantity of output

Many of these points can be tackled by executing a Life cycle assessment (LCA) and life cycle costing (LCC) for a full life cycle, like plastic-to-plastic recycling.

Challenges and Opportunities

Each step of the value chain has its own challenges which need to be addresses in an interconnected manner. But where challenges lie, opportunities can be found. In the table below challenges and opportunities are brought in juxtaposition to stimulate solution thinking.

	Challenges	Opportunities
Feedstock	• Today, most feedstock consist of non-renewable, fossil-based naphtha and natural gas. Only 1% of raw material input originates from biobased materials.	• Increasing biobased materials and plastic waste streams for feedstock (see thermochemical recycling)
Refining	• Plastic production is part of a complex petrochemical industry (see Sankey) and has a connection to important markets (artificial fertilizers, solvents and chemicals), making adaptations in the value chain a challenge. • Refining and compounding are optimized for the specific composition of naphtha, hence would need to be adapted when alternative feedstock is used	• The cracker, used for refining fossil-based naphtha, also supports various opportunities in the circular economy, where waste can be transformed into feedstock through a refining step (see thermochemical recycling). • During the polymerization process, recycled materials can re-enter the value chain. Monomers that are obtained through recycling processes can be re-used as raw material (see depolymerization).
Manufacturing	• Large quantities and a high variety of additives (see table) in products complicates recycling and hence, effectively closing the loop. • Used Additives can be toxic and high variety complicates registration and tracking of additives. • Manufacturing is energy intensive, and also re-manufacturing of recycled plastics requires a lot of energy. Re-use, repair, refurbish, remanufacturing does not need a new manufacturing step.	• Dissolution can be used to remove contamination, or separate additives from polymers or polymers from each other (see dissolution). • Chemical Regulation (like REACH in Europe) can prohibit reintroduction of plastics with substances of concern. • Low energy methods for manufacturing can additionally support making the value chain more circular.
Retail and Use	• Packaging is specifically designed for single use and reuse or recycling goals are not included in the design. This results in high waste quantities. • For plastics from other sectors, recycling percentages are low as well, even though they are not single use. This is mainly due to additive presence, inadequate product design and lack of waste management infrastructure. • Textile and apparel tend to lose microfibers, mainly during washing.	• Re-use, repair, refurbishing and remanufacture are needed design strategies to be used for extending the use phase of plastic products. • Biobased feedstock, reuse and recycling are design options for short lived items like packaging. • Deploying washing machines standard with fibre collection technology is a solution to tackle the problem of microfiber formation.

	Challenges	Opportunities
Sorting	• Collected plastic waste is mixed and/or contaminated with other waste which hampers sorting optimization and results in quality issues. • When plastics are collected separately, quality can be enhanced. However, contamination levels can still be high, a result of lack of awareness, insight and discipline in plastic separation. • There are losses during the sorting processes, which are sometimes more than half of the plastic waste stream. • Further professionalization of the informal sector as well as regulatory development is needed to ensure that non valuable and/or environmentally damaging flows, like single use packaging, are collected as well.	• Source separation of plastics, such as refund systems, diminishes the contamination and complexity of sorting and recycling and offers most perspective on and success for market re-entry. • Key for functional waste separation is consumer and school education.
Mechanical (physical) recycling	• Only a fraction of plastic waste is actually suitable for mechanical recycling because of its design. Plastics with additives, mixed waste streams, or highly contaminated material cannot be mechanically recycled. • A key challenge during physical recycling is preserving plastics performance quality. Through mechanical recycling steps such as heating and shredding, quality losses can occur and should be kept to a minimum.	• Mechanical recycling is a good recycling option when input streams are pure, as polymers are kept intact retaining most material value against the least additional effort (costs and energy), making the business case for mechanical recycling is theoretically most practical. • Dissolution is an innovative recycling technology, which can increase the number of plastics that can be physically recycled. Additives and other contaminations can be removed by dissolving the polymer in a solvent. This has huge potential for mono-flow streams of plastics dealing with quality issues due to additives, such as expanded polystyrene for the building industry with a now forbidden fire retardant, WEEE plastics or automotive plastics.
Depolymerization	• For depolymerization, high-quality feedstock is required, containing clean and mono-stream plastic waste. This is difficult to obtain from mixed plastic waste streams such as packaging.	• Depolymerization offers a circular potential for plastics that cannot be mechanically recycled, such as more degraded plastics, plastics with additives, specific contamination or multilayers. Research is continuous, and promising methods keep on developing.
Thermochemical recycling	• For waste to function as raw material input, processes need to be aligned with composition and quality demands from the refining and compounding industry. • Disturbing polymers affect output quality, such as PET containing oxygen, or PVC containing chloride (corrosion). • Many treatment steps impact the energy intensity and can impact business model.	• Thermochemical recycling can play a key role in taking up plastic waste in mixed streams, which are unsuitable for mechanical recycling and depolymerization. Furthermore, dedicated pre-sorting for thermochemical recycling technologies could potentially be a very feasible option.

THANK
THANK
THANK
Have A
Please return to a participating store
WARNING: TO AVOID DANGER OF SUFFOCATION, KEEP THIS PLASTIC
BABIES AND CHILDREN. DO NOT USE THIS BAG IN CRIBS, BEDS,
PLAYPENS. THIS BAG IS NOT A TOY. NOT RECOMMENDED FOR FOOD STOR

THANK YOU
THANK YOU
THANK YOU
Have a Nice Day
for recycling.
BAG AWAY FROM
CARRIAGES OR
AGE.
2
HDPE

Chapter 5

An action perspective

As we have seen in earlier chapters, the plastic value-chain is complex and a cross-border market with many actors. In chapter 3, opportunities to apply the R strategies are introduced. However, one will stumble upon several challenges when doing so. A circular transition for plastics requires a new way of design, production, usage and dealing with waste. Collaboration is needed from the beginning of the value-chain to the end, within eco-systems and increasingly between various sectors. Action will be required from all stakeholders: industry, private actors, consumers, waste managers, national and local authorities as well as from knowledge institutes. There is no blue print for re-designing the value chain. It demands creativity, innovation and applicability in multi-regional contexts. A circular transition can be expected to be 20% about technological innovation and 80% about social innovation.[12]

This chapter deals with the action perspective by different stakeholders and explores tools that enhance change.

A governmental perspective

When a crisis becomes imminent and the market cannot or does not want to act, the government should step in. We believe this is the case for plastics.

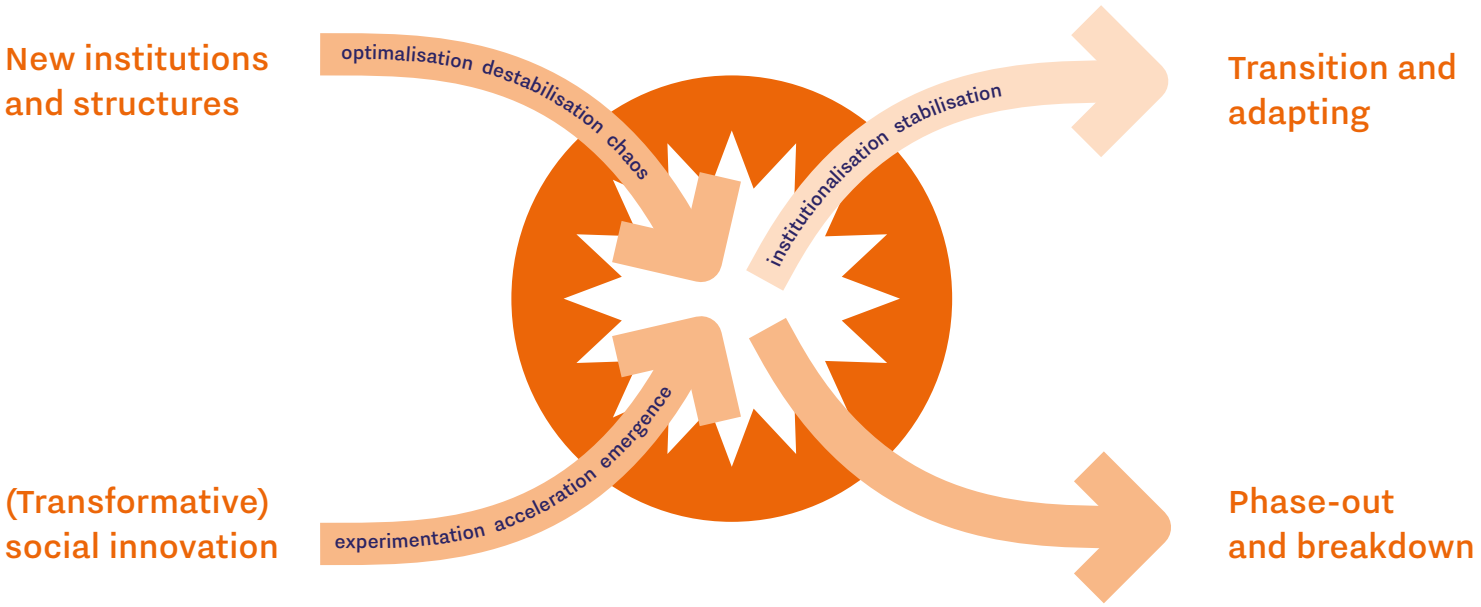
In this case, apart from technological optimizations, regulation and societal action has to step-in to set-up a mechanism and create the boundary conditions that change the status quo. As the value chain of plastics crosses border and scaling up is a necessity, this inevitably means international alignment. Governments can set ambitions and identify priority area's for action; governmental focus on plastics is essential to build up a critical mass of stakeholders that can take action. Plastic is one of five priority sectors that led to the EU Strategy for Plastics in a Circular Economy, which aims to transform how plastics and plastic products are designed, produced, used and recycled. Among its targets is that all plastic packaging should be reusable or recyclable by 2030.

Ambition and focus alone are however not enough to guarantee success. The existing system has to be tweaked. Government can work on a set of interventions:

- Fostering legislation and regulation
- Intelligent market incentives (carrot & stick)
- Access to financing for new initiatives
- New Knowledge and Innovation initiatives
- Behaviour Change
- International cooperation

Dynamics of transitions

Source: Drift (Erasmus University) Transition Management



Regulation in the value chain

In many countries the infrastructure for waste management has not grown along with population growth and economic development.
Financing and investment in waste management can support the development of both up- and down-stream measures to support the sustainability of plastics.
Although recycling and recovery is the very last step in a circular economy, setting up regulations for waste management, is often a first step on the road to circularity. We therefore include some general recommendations for successful waste management learned the hard way in the Netherlands during over 150 years of practice.

Toolkit for setting up an adequate waste management system

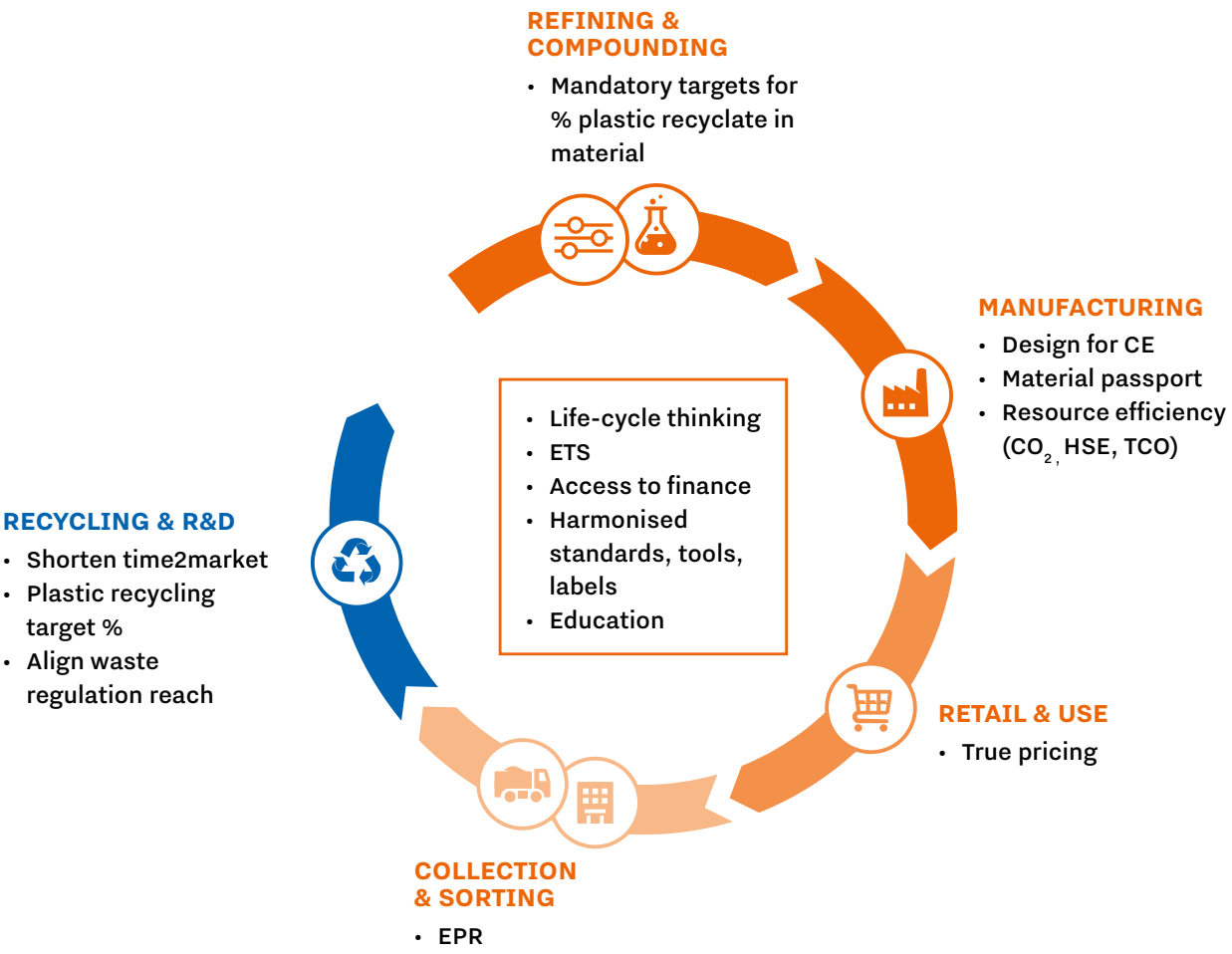
Critical content factors

- Waste hierarchy (in the Netherlands since 1979)
- Extended Producer responsibility (EPR) based on the polluter pays principle
- Minimum standards for treatment
- Landfill and incineration taxes combined with landfill bans for certain flows
- Separate collection of valuable waste streams like plastics

Essential system aspects

- Adequate Waste infrastructure planning system
- (Municipal) waste tax that covers all costs including for example landfill after-care
- Cooperation between government authorities
- Quadruple innovation by involvement of authorities, knowledge institutes, in-dustry and consumers
- Consensus on data
- Monitoring & enforcement system

Tools to enhance circular plastics



The use of effective market-based instruments is mentioned to incentivize changes in the plastics value chain that support sustainability. Taxes, for example, can be applied to penalise specific products (or chemical additives) and less preferable waste treatment practices (i.e. landfilling or incineration). Well-designed deposit refund schemes (DRS) and extended producer responsibility (EPR) policies can cover the costs of waste management and help to create a market for products which prevent waste or are easy to re-use or recycle.

Extended Producer Responsibility (EPR)

Extended producer responsibility is a key element of waste management. EPR shifts the responsibility of waste management partially to manufacturers as it describes the producer's legal obligation to pay for arising pollution from its produced plastic products, like environmental externalities. This mechanism encourages manufacturers to invest in sustainable design of products to improve collection and recycling opportunities. EPRs are most prominent in plastic packaging but also enforced on electronic and electrical equipment.[13] There is a variety of how EPRs are approached, most common are take-back arrangements, deposit/refund, and advance disposal fees (ADF). Because realization of EPRs require efforts from both government, local authorities and a variety of producers and importers, most companies to which EPRs apply work with or are part of Producer Responsibility Organisations (PROs.)[14] EPR policies are applied in EU, the US and Canada and are in development in many other countries.
By combining EPR with Eco-modulation a price differentiation can be made for good (reusable or recyclable) versus bad products or packages.

Bans and levies

More and more countries take up policies regarding the usage of single-use plastic items to limit their waste production. Already over 60 countries have adopted bans or regulations, such as pricing of plastic bags, on single- use plastic items.[12]

Circular Procurement for Plastics as pull factor

Public procurement is a significant percentage of a governments budget (EU: 14% of GDP).[15] If directed at circular initiatives it can be a tremendous pull factor for new initiatives. Buildings, catering, uniforms all can be tendered circular.

Deposit return schemes (DRS)

Deposit return schemes is a popular tool that allows for separate collection of bottles, beverage card boxes and cans. DRS can be part of EPR and is applied in many western nations. By adding a surcharge on products consumers are incentivised to return waste to collection points. This passes financial responsibility down to end-consumers which has shown to be effective with an almost 90% rate in Europe and is thereby one of the most efficient instruments to tackle plastic leakage into the oceans and the environment.[12] DRS can reduce drink containers in the ocean by up to 40%.

Waste Shipment limitations to boost national CE plans

Until 2016, China imported two-thirds of the world's plastic waste, mostly mixed or of low quality, everything unwanted and too hard to deal with for other countries. However, due to new national goals of boosting China´s own circular economy and recycling capacity, and getting in the critical spotlight of a more and more sustainability-aware global community, China announced to the World Trade Organization to put in place contamination standards for imported plastic waste in July 2017. In 2018 this act, known as the Chinese National Sword, was enforced which suddenly banned imports of 8 plastic types. Malaysia, Vietnam, the Philippines and Thailand are also known for waste export opportunities and are starting to follow China's example by setting higher quality standards on imported plastic waste to keep up with their own national agendas on sustainability goals. The reduction of low-quality plastic waste trade forces export countries to deal with their own waste, stimulating better waste management and recycling systems.

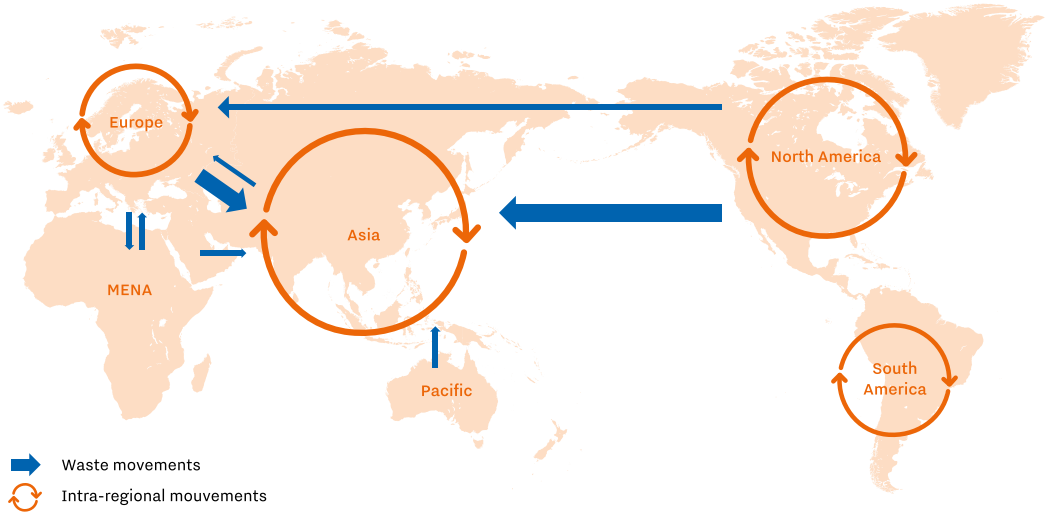
Since 2019, solid plastic waste has also been recognized by the Basel Convention which aims to limit global trade in hazardous waste, and therefore prohibiting contaminated plastic waste export. Unfortunately, guidance and enforcement tools are not provided which weakens implementation.[12]

Transnational trade in plastic waste

Source: Interpol (2018)

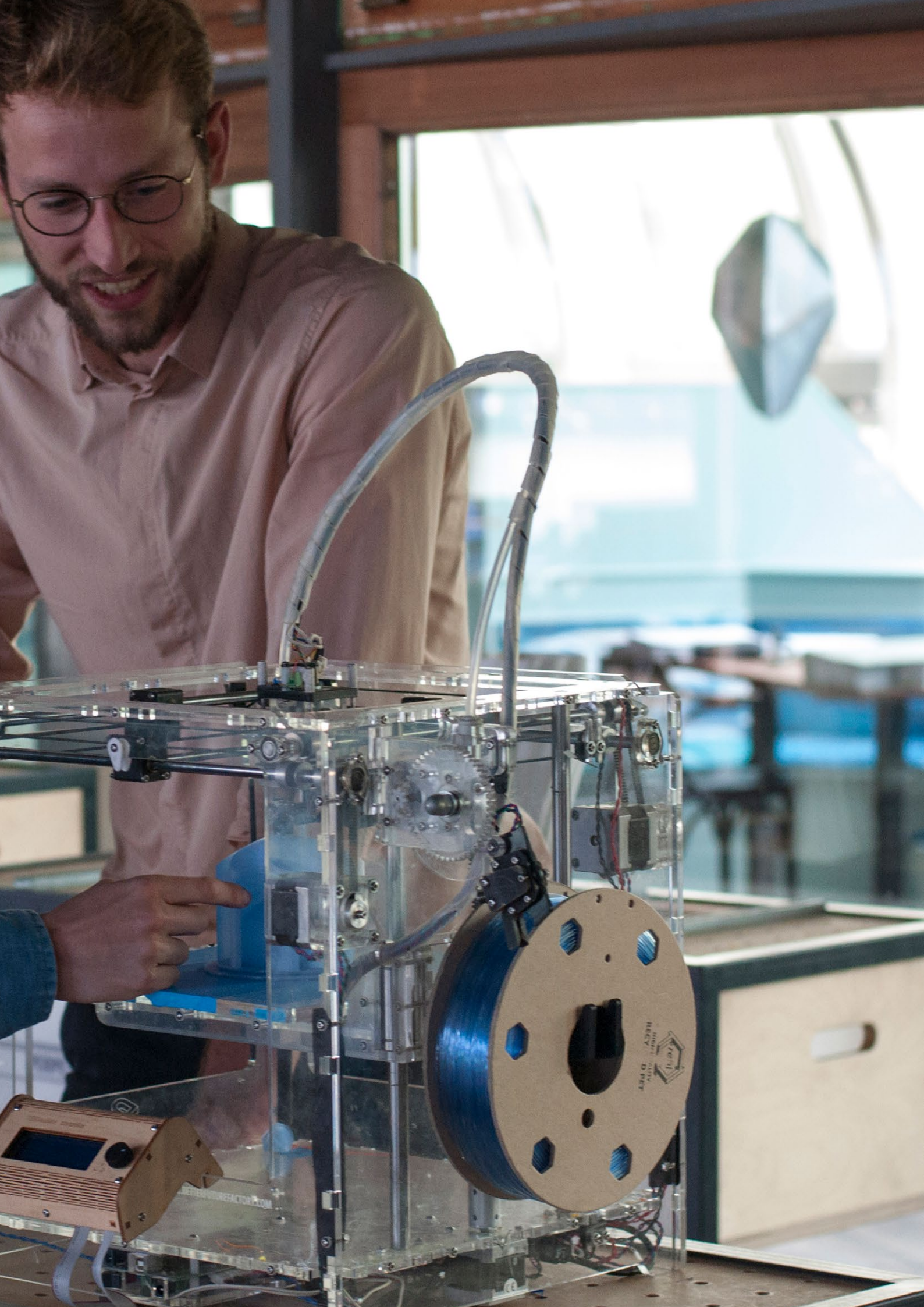
Emerging from interpol data collection bases on 39 countries contributions

Source: Strategic Analysis Report Interpol 2018.



Plastic exporters are now required to notify and obtain consent from importers for mixed plastic bales through the Prior Informed Consent procedure.

Waste exporting countries confronted with the impact of the China's Operation National Sword are however slowly taking responsibility. In November 2020 The House of Representatives passed Australia's first Recycling and Waste Reduction Bill that bans the export of Australia's waste plastics, glass, tires and paper and modernizes product stewardship laws.



Initiatives, Pacts & Alliances

A growing awareness of the global nature of the plastics challenges and the need for international cooperation is reflected in international initiatives for marine litter, such as the UN Global Partnership on Marine Litter and the G7 and G20 action plans.

Individual cities and organizations worldwide are also taking actions to contribute to making plastic more sustainable. For example, San Francisco International Airport is banning the sale of plastic water bottles. As of August 2019, passengers will only be able to purchase refillable glass or metal bottles at the airport.[16]

Leading multinationals such as Coca Cola Company, Mars, M&S, PepsiCo and Unilever are also increasingly setting sustainable targets for plastics. For example, "A commitment to 100% reusable, recyclable or bio-based plastic by 2025 or earlier" was set during the World Economic Forum 2019.[17]

In the table below we have listed a number of initiatives as an illustration of the momentum for action. There are many more promising initiatives in international commodity chains, such as the Pacific Ocean initiative Norwegian or Taiwan's comprehensive plastic bans, to name a few.

INITIATIVE	ORGANISATION	PURPOSE
European Plastic Pact	Initiated by NL and FR and at initiation signed by 15 EU Member States and 66 companies	Brings together frontrunner companies and governments from across the whole value chain to accelerate the transition towards a European circular plastics economy. They work together to-wards four goals aimed at design, responsible use, recycling capacity and the use of recycled content. The Pact supports this work by offering a unique platform to exchange ideas, display good practices and discuss challenges, needed to build a new circular default for all to follow. Started by The Netherlands and France,137 parties have signed the European Plastics Pact initia-tive coming from 15 countries in Europe, including, Switzerland, Norway and the United Kingdom; one signatory comes from the United States.
Circular Plastics Alliance	European Commis-sion	Over 245 stakeholders from public and private sector have signed the goal to increase the recycle content used in produc-tion to 10 million tonnes in 2025 to increase Europe's recycled plastic market, a 150% increase of todays practice.
Global Tourism Plastic Initiative	UN Environment Program and the World Tourism Or-ganization, in collab-oration with the Ellen MacArthur Founda-tion	Parties across the whole tourist value chain join to improve the sector´s plastic footprint, exchanging knowledge and enhance collaboration between (local) public-and private stakeholders such as fostering procurement practices. The Initiative has set goals for 2025 to eliminate unnecessary plastic items and pack-aging and switch to 100% reusable, recyclable or compostable material. It is furthermore aimed on establishing a performance benchmark for the sector.
Global Plastic Platform	UN Environmental Assembly	Member states, businesses and third parties showcase and access information to support countries and cities that have made plastic reduction commitments. It facilitates the sharing of experiences, the establishment of new policies and inspiration for new commitments.
The New Plas-tic Economy Global Com-mitment	Ellen MacArthur Foundation	Unites businesses, governments and other organizations glob-ally behind a common vision and targets, to address plastic waste and pollution at their source.
Alliance to End Plastic Waste	Alliance to End Plastic Waste	Cross-value group of global companies in the North and South America, Europe, Asia, Africa, and the Middle East that has committed over 1 billion US Dollars. Goal is to invest 1.5 billion US Dollars over the next five years to help end plastic waste in the environment
Common-wealth Clean Ocean Alliance	The Commonwealth	The UK; Ghana, Sri Lanka, New Zeeland and Vanuatu are collaborating to tackle marine plastic in partnership with busi-nesses and NGOs. Each country has pledged to ban mi-crobeads in rinse-off cosmetics and personal care products are well as cut plastic bag use by 2021.

INITIATIVE	ORGANISATION	PURPOSE
Circulate Capital	Circulate Capital	A 90 million US investment fund funded by companies includ-ing Coca-Cola, Unilever, P&G, Danone and Dow, set up to combat marine plastic pollution in Asia.
#breakfree-from plastic	#breakfreefrom plastic	A global movement championing a future from plastic pollu-tion. Since its launch in September 2016, nearly 1.300 organiza-tions globally have joined the movement to demand industry makes reductions in single-use plastics and to push for lasting solutions.
The UK Plastics Pact	Waste and Re-sources Action Pro-gramme (WRAP)	The first global network of agreements to address plastic waste on a voluntary basis (with others in France and Chile). WRAP sets out four targets for 2025 to address circularity and eliminate problematic or unnecessary single-use plastic.

18

International collaboration

Only by international collaboration we will achieve sizeable success as the plastics value chain spans the globe. We illustrate it with actions from the Netherlands

A small country with larger plastics ambition

The Netherlands is active in EU context on plastic related topics like a ban on microplastics in cosmetics and abrasive cleaning products, the revised PRF directive, the Single Use Plastics directive and influencing the new circular economy package, the European Green Deal and the Zero Pollution Ambition.
The Netherlands is actively cooperating with UNEP's regional office for Latin America and the Caribbean on the theme of waste policy for small island states. Planning, design and implementation of an effective waste collection and treatment structure is given priority in order to prevent litter from entering the marine environment, either through diffuse pollution or through storms.
The Netherlands is also active within PACE, Platform for Accelerating the Circular Economy. Plastic is one of the focus areas and so far has been shaped through the Global Plastic Action Partnership (GPAP), which helps governments and companies to translate political and business ambitions into concrete action plans. Pilots are underway in 3 countries: Indonesia, Ghana and Vietnam.
The Netherlands also supports the UNEP Global Partnership for Marine Litter. The aim is to identify and fill the knowledge gap through research, learning from each other through partnership and promoting and coordinating global reduction goals.
NL deployment in a UN context is aimed at the Working Group (AHOEWG) / UNEP on global approach Marine Litter and advices on the global fight against marine plastic pollution (litter) and microplastic from all sources but mainly from land sources.

The Netherlands is one of the 29 Consultative Parties to the Antarctic Treaty and is actively committed to protecting the Antarctic environment. The priority of the Netherlands lies in the regulation of tourism.
The Dutch Plastic Pact (Plastic Pact NL) was launched in the Netherlands in February 2019, and it is the first step to make single-use plastic products and packaging more sustainable and suitable for reuse. Until today, 97 parties have signed the pact, including producers, retailers and the Ministry of Infrastructure and Water Management (IenW).
In March 2020 15 EU Member States and 66 companies signed the European Plastic Pact during as a result of political discussions led by the Danish, Dutch and French governments.

Another challenge to bear in mind are financial aspects of closing the loop for plastics. In a linear economy the externalities of plastics, like cost associated to its impact on the environment, are not reflected in the price of plastic products. Because of this, no one feels directly responsible for the issues caused.
Besides, plastic Recyclate has to compete with virgin plastic made from oil. When the oil price is low, the recycling market suffers. Furthermore, a significant part of market for plastics waste today, especially mixed plastics, has a value chain deficit. The costs of collection and recycling are higher than the positive value of the plastic fraction that can be brought to the market. In other words, money needs to be added to the system to ensure that plastics are collected and valorised.

Access to funding

To stimulate innovative processes that help to create a preferred circular ecosystem subsidies are required. In many countries, but also in Europe, subsidy schemes are available. H2020 and from 2021 onwards, Horizon Europe will offer subsidy schemes for enhancing plastics circularity.

The business perspective

- Entrepreneurs have the guts and imagination to take risks, invest and accelerate change. It is business that delivers scale to the global CE transition. Global brands and retailers, especially after COVID-19, should realize that this is about resilience and about their future markets. To paraphrase former CEO Feike Sijbesma of DSM: “how can you claim to be successful as a company in a society that fails”. CE for plastics is also business opportunity.[1]
- Think how markets can grow with sharing, service or platform models
- Imagine the additional value created from resources by lifetime extension for example giving your phone a second a third or a fourth life.
- Saving resources, energy or water in plastic product production is directly lowing costs
- CE is collaborative: working together as well as mutual dependency in a chain increase resilience and reduce risks.

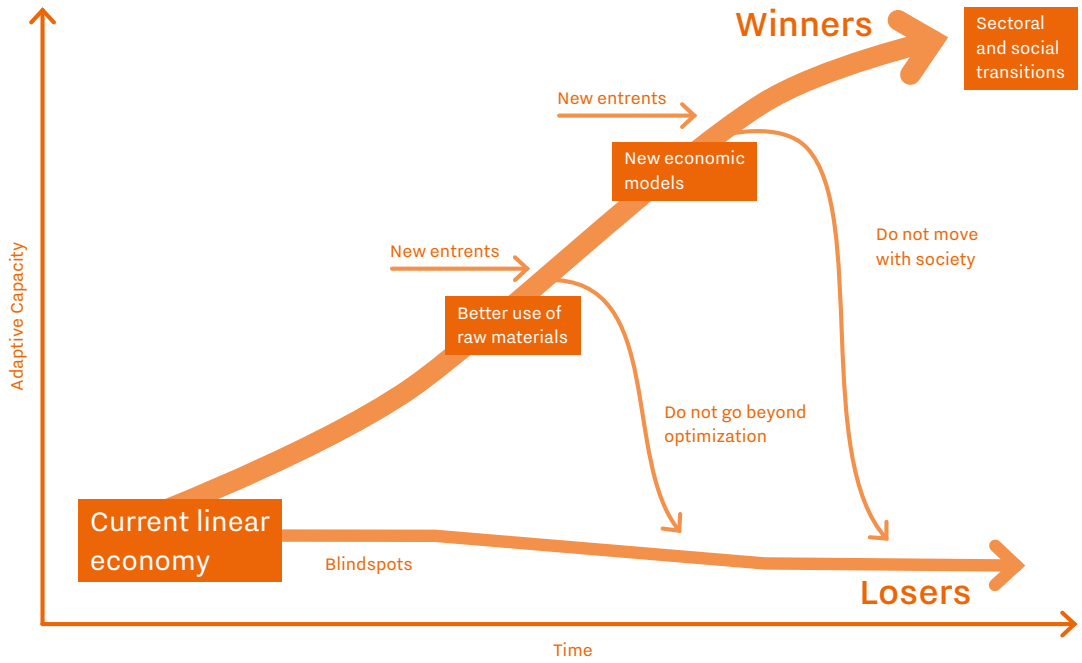
A Circular Economy calls for a profound transformation in the way we work and produce, and the way we design, teach, invest, and buy. First movers potentially have the biggest advantage. It often starts with a focus on waste management and resource efficiency, but it is the start of a journey that should lead to new economic models and eventually a sectoral transition.
The secret of Dutch Entrepreneurs, often considered frontrunners in circular innovations, is their learning by a doing mentality. With this mentality you either win or you learn. If entrepreneurs wait for the perfect cross border regulatory conditions in place it is probably too late for the planet. Besides that, front runners have the biggest market opportunities.

Awareness & Behaviour aspects

We sometimes jokingly say that people over 40 are more difficult to educate but educating the young generation, the leaders (and consumers) of tomorrow, on plastics and littering can be quite effective (also to set households into motion).
The National Test Centre Circular Plastics, a non-profit organization that focuses on researching technology and value chain approaches for circular plastics also pays attention to awareness creation amongst youngsters. With their program “Plastic Quest” they invite primary school pupils to explore how to treat plastic in a proper way to prevent littering in the environment but also how to capture the material and avoid incineration.
There are various examples of Plastic and Litter programs at schools (like Eco-Schools).

Knowledge Institute perspective

Knowledge institutes develop new insights, enable valorisation of their knowledge and create awareness. It is also about setting R&D new priorities for maximum societal impact.



Source: Illustration courtesy Drift (Erasmus University)

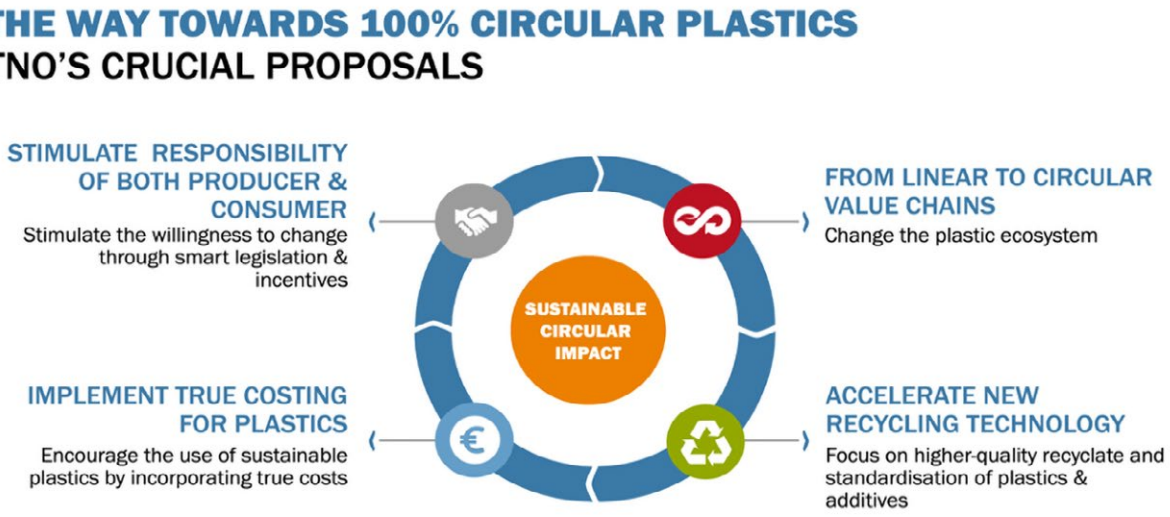
TNO : The Netherlands sets trends for the Circular Plastics Economy

Down sides of plastics – plastic soup, micro- and Nano plastics, fossil fuel depletion and CO2 emissions – are substantial and effect our environment and health. In 2018 the average Dutch citizen produced 55,3 kg plastic waste. One third only was recycled or reused, and half of that lost substantial value, with other words was downcycled. Obviously, all of this leads to diminishing societal acceptance and threatens the license to operate for the plastics industry despite plastics' unique properties.
TNO's conclusion described in the white paper "Don't waste it" is to keep the bright side and solve the dark side of today's plastics. A systemic transition is needed to enable the sustainable production and use of circular plastics.

Instead of waste-based reasoning the TNO model is based on the market and market demand, and therefore focuses on value. This has consequences for the further application of prevention, reuse, redesign, different kind of sorting and other logistics, as well as on the use of different recycling technologies.

The solutions in the TNO white paper are based on circular value networks, technological innovations, policy and behaviour. In addition, the new circular business models for this strengthen the economy.

Such an integrated approach can make the Netherlands a country that provides guidance. As a result, by 2050, 87% of the then expected plastic waste generated in the Netherlands can be recovered (73% as polymeric raw material for new plastics, 14% prefabricated as part of a product). TNO bases this outcome on a new internally developed PRISM model.



Future visions on plastic

To round it up we share four independent visions on the future of plastics from different perspectives: NGOs, Knowledge perspective and Business at a national and international level.

Utrecht University – Chemical Upcycling of Plastics

A Knowledge-driven Approach towards Circular Materials

Plastic waste has developed in recent years into a pressing Environmental and Climate problem as almost all plastics are still produced from fossil carbon-based feedstocks and plastics is leaking into the environment, such as rivers, lakes and seas, massively. Clearly, there is a need for a concerted action, including proper legislation, to make our society more sustainable. Plastic waste, however, offers great opportunities for the Circular Economy. If today's externalities can be accounted for and its circular economic value is recognized plastic will continue to play a key role in 2050. This has inspired many scientists, from academia and industry, to produce valuable chemical products from plastic waste, in a process which is called upcycling. Furthermore, there is a growing trend in which municipal and agricultural waste is used, instead of fossil fuel, for producing existing as well as new chemical building blocks for the making of circular materials, a.o. plastics. This trend is a crucial element of a vision on a future Climate Neutral Chemical Industry.

Our research group is actively contributing to both fields of research, together with partners at the Utrecht Science Park, such as TNO and Hogeschool Utrecht, as well as with other partners, including for example those involved in the Strategic Alliance UMC/UU/WUR/TU/e and NIOZ. By sharing expertise and equipment, we believe we can accelerate the knowledge-driven transition towards the synthesis of circular materials.

Together with other partners we actively work on new relevant topics like (a) the synthesis of coatings starting from building blocks from abundant biopolymers, such as lignin and chitin; (b) chemical recycling of plastics, including polyethylene and polypropylene; and (c) the collection and detection of micro- and nano-plastics in the ocean, another priority topic for the industry.

A recent example of successful collaboration can be found in the review paper on plastic recycling, together with researchers of TNO, which has been published in Angewandte Chemie (https://doi.org/10.1002/anie.201915651). This article serves as blueprint for future developments in this important field of research. We showed that each of the currently available chemical recycling processes is applicable for specific plastic waste streams. Thus, only a combination of different technologies can address the plastic waste problem. These scientific and technological developments will have to go hand in hand with better policy frameworks, improved collection and sorting infrastructure and platforms connecting all the important stakeholders.

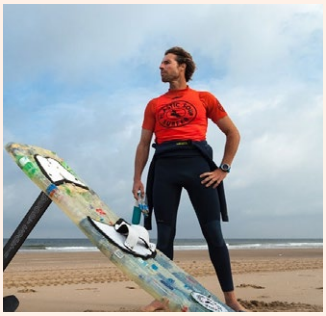
We believe the future is bright for chemists, materials scientists and chemical engineers to find new and improved processes for chemical recycling of a wide variety of commonly used plastic materials, and much progress can be expected in the years to come.

Joining Forces to Make our Society More Circular and Sustainable!

Bert Weckhuysen

Distinguished University Professor Catalysis, Energy & Sustainability
Scientific Director of ARC CBBC & MCEC Utrecht University

A change of mindset and design



I once visited a plastic-waste sorting installation in the Rotterdam harbour. It was a hot day and the stench of the discarded packaging smeared with rotting leftovers made me gag. I was awe-struck by an enormous mountain of plastic waste at the mouth of the installation; the steaming remnants of our throw-away society it seemed to me.

In theory 250 different types of plastic can be recycled when sorted by type. In practice the system is flawed. Not because of the material itself but because of its application.
Packaging has the obvious goal of keeping products save and fresh. But plastic being mouldable, cheap and light is a magnificent marketing tool, creating demand where none existed before. Plastic is the catalyst to our throw-away society. And our throw-away culture is the root cause of plastic pollution; from plain littering to failed waste management. Thus: To take on plastic is to take on our society. Yes; through new innovation we may be able 'recycle' more. But it will only strengthen the status quo. There is a moral question here. To what extent will we proceed to have plastic catalyze the throw-away society?

For packaging alone, we can make do with significantly less types of plastic. We can invest in reuse options. We can invest in take back schemes. This is what will shrink the mountain of plastic waste. This transition will increase circularity: of materials and in the minds.

Merijn Tinga
Plastic Soup Surfer

Companies form Solutions - A Private Sector Approach

The Alliance to End Plastic Waste is an international non-profit organisation that unites policy makers, non-governmental organisations, industry players and local communities around the world with their shared vision to end plastic waste in the environment. The scale of the global plastic waste challenge calls for the collective action and collaboration of diverse stakeholders from across the plastic value chain to solve this complex problem.

The trends are clear – 11 million tons of plastic waste leak into the environment every year and that will be 29 million tons in 2040 if we do nothing about it. 45% of today's plastic waste leakage is from rural & remote areas where waste collection economies don't work including hotspots in Asia with coastlines most vulnerable to plastic waste leakage. And with three billion people with limited to no access to organized waste management systems, the cost of managing plastic waste for governments and businesses is in the hundreds of billions and growing.

Swift action by both public and private sectors is a must if we are to arrest this growing waste challenge. Since 2019, the Alliance has rallied over 50 member companies, strategic allies and supporters, bringing together a diverse network of resources and expertise. We are working together to accelerate solutions, engage communities, and catalyse investments. Our work focuses on delivering a portfolio of solutions directed at infrastructure, innovation, education and cleanup.

The Alliance with the support of our members, is are targeting USD1.5 billion dollars over five years to our mission. And by 2025 and beyond, we expect to deliver investable models and partnerships that will demonstrate zero plastic waste in multiple cities and divert well millions tons of plastic waste through Alliance projects in more than 100 at-risk cities. We want to support healthy livelihoods for over 100 million lives across 100 communities by enabling local ownership of waste management; and unlock at least five times our investment and much more to accelerate actions and solutions to end plastic waste and build sustainable cities.

By end 2020, the Alliance has already approved over 20 projects across cities in Asia, Africa and Latin America. For more information on our projects, see here. Progress report: please download here.

Jacob Duer
President and Chief Executive Officer Alliance to End Plastic Waste

A key role for innovative chemistry

If there is one thing I have tasted here in South Limburg: the ability to adapt to the changing social and economic tides. From an agricultural era via intensive mining to the leading ecosystem for innovative chemistry and materials. Even now, now the call is growing louder for acceleration in the transition to a sustainable circular economy, Limburg is taking steps forward. The circular economy - an opportunity for economic growth and future prosperity.

We have set a strong ambition with a broad alliance of companies, knowledge institutions and governments in and around Chemelot Industrial Park and the Brightlands Chemelot Campus, a unique combination of innovation and real life operation. We are taking the lead in realizing the first Circular Hub in Europe: Chemelot Circular Hub. With an integrated investment agenda - the Circular Economy Action Plan (CEAP), we stand for making chemical processes and plastic materials, economy and society circular. And directly in line with the needs of consumers, the markets and society, we contribute to the climate ambitions.

Chemelot Circular Hub is not just a plan. We are already on our way. With e.g. companies like QCP (mechanical recycling), Ioniqa (recycling PET via depolymerisation into building blocks), Plastic Energy/SABIC, Recycling Technologies, Clean Gas Company (pyrolysis of plastic waste to cracker feed), RWE (gasification of household waste to hydrogen) and Niaga (designed to recycle carpets) and the R&D institutes Brightsite (sustainable chemical processes), Brightlands Materials Center (circular plastic materials and products) and Aachen-Maastricht Institute on Biobased Materials (biobased plastic materials), we already have crucial building blocks for a circular economy.

Central to our vision is the realization that the chemical and materials sector can play a key role in a broad solution and development-oriented context. From fossil to circular raw materials from waste by mechanical and chemical recycling and by using sustainable energy sources. However, just transforming the chemistry is not enough. For us, “Circular Hub” stands for an economic and social crystallization point, for connecting the chemical and materials ecosystems with the waste and agri-food ecosystems. These connections are crucial for closing the carbon cycle. We believe in the impact of a broad investment, an integrated movement to come to the required system change, to a circular economy. By realizing strong partnerships along the cycle. With a focus on driving innovations to scale, building circular competences, realizing the required infrastructure and investing in the (regional) circular society.

That is why we continue to join forces with other chemical clusters, with the waste sector and the agri-food sector and with relevant cross-border networks. We are looking for partnerships in The Hague and Brussels. I am convinced that we can only achieve sharpness in the implementation of the change tasks together. From a healthy investment climate we can achieve meaningful results for the future-proof development of the circular economy and society at large.

Chemelot Circular Hub – Leading Circularity!

Bert Kip, CEO Brightlands Chemelot Campus, Chair Board Chemelot Circular Hub

Colophon

The Netherlands Organization for Applied Scientific Research (TNO) is an independent research organization. We connect people and knowledge to create innovations that boost the sustainable competitive strength of industry and well-being of society. Now and in the future. This is our mission and it is what drives us, the over 3.500 professionals at TNO, in our work every day. We work in collaboration with partners and focus on transitions or changes in nine social themes that we have identified together with our stakeholders.

At Holland Circular Hotspot (HCH), we believe that creating a circular economy calls for a profound transformation in the way that we work and produce, as well as the way that we design, teach, invest and buy. For this reason, we strive to connect the global circular community by inspiring cross-sectoral collaborations, stimulating the exchange of knowledge and innovations, and boosting circular entrepreneurship.

Authors
Anna Schwarz, Netherlands Organisation for Applied Scientific Research
Rob de Ruiter, Netherlands Organisation for Applied Scientific Research
Esther Zondervan, Netherlands Organisation for Applied Scientific Research
Freek van Eijk, Holland Circular Hotspot
Lia Huybrechts, Holland Circular Hotspot

Website
www.tno.nl
www.hollandcircularhotspot.nl

Email
rob.deruiter@tno.nl
info@HollandCircularHotspot.nl

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