The State of Sustainable Packaging

Beyond Closing the Loops: PackForward

Netherlands Institute for Sustainable Packaging

"The State of Sustainable Packaging shows which innovative steps the packaging industry has to take to become intrinsically sustainable. This destination can only become within reach through cooperation between business partners in the packaging chain, directing government action and consumer involvement."

Prof. Jacqueline Cramer,
Chair Committee of Independent Experts at KIDV,
The Netherlands

"If I only commit to what I already can, I don't inspire others and I give people the right to say, "You're not going fast enough". Putting your money where your mouth is, will enable me to put pressure on my own organisation to make the harder choices."

Robbert de Vreede,
Executive Vice President Global Food at Unilever

"Today, waste streams are moving towards the lowest cost point for processing in Europe. This generally doesn't have the best environmental impact. We can only solve this with a harmonised and strictly controlled system and by working on value for waste."

Diederik Samsom,
Head of Cabinet of Executive Vice-President Frans Timmermans
at the European Commission

Colophon

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Dear reader,

On behalf of the Netherlands Institute for Sustainable Packaging, it is my pleasure to present *The State of Sustainable Packaging* to you. With this publication, we want to involve packaging businesses, the government, societal organisations and knowledge institutions in the development and implementation of a robust strategy for realising sustainable packaging towards 2050.

As I write these words, the world fights against COVID-19. This pandemic has had an unprecedented impact on our society. It is hard to predict when this uncertain time will end. The COVID-19 crisis has also had a major impact on our economy. Many businesses face an uncertain future. Other businesses struggle to keep up with demand or learn how to reshape their business model so they can operate and make a profit under these new circumstances. The world has been thrown off balance. We not only have to work on improving public health, but also on economic continuity and recovery.

Where do we even begin? What will the new equilibrium be? I will not go so far as to claim that the current crisis might suddenly bring about a fully sustainable society, once everyone is back in business. Our existing production and consumption patterns are too deeply interwoven with our ingrained lifestyles for it to even be a possibility. Things will not change overnight, yet I still view this period as a time to reflect. These past months, I have not had to rush to and from work every day, shop less and when I do I buy more in bulk, and the digital communication systems that we have in place are performing extremely well. One of the first structural changes will therefore probably involve an increase in working from home, leading to fewer traffic jams, more scheduled instead of spontaneous interaction with colleagues, more webinars, etcetera.

When reflecting, we force ourselves to ask: “What are we doing?” To be more specific, in light of the topic of this publication: how will we deal with our needs, products and the packaging materials these require in the future? Will e-commerce become even more popular and will that pave the way towards better and more sustainable packaging practices? Will we go on fewer shopping trips and purchase larger portions of food instead of increasingly smaller portions, as has been the case thus far? Will we truly begin to grasp the importance of making our economy circular? What degree of circularity can we achieve?

Questions like this are the foundation of *The State of Sustainable Packaging* and provide answers and direction to the packaging challenges we are facing. This publication will help you make decisions that contribute to higher yields for recycling, a growing market for reuse and ultimately an intrinsically sustainable society with zero emission of harmful substances into the natural environment. After all, a healthy society is a sustainable society. This State of Sustainable Packaging is intended to help pave the way. We look forward to joining you on this journey.

Chris Bruijnes
Director of the Netherlands Institute for Sustainable Packaging (KIDV)

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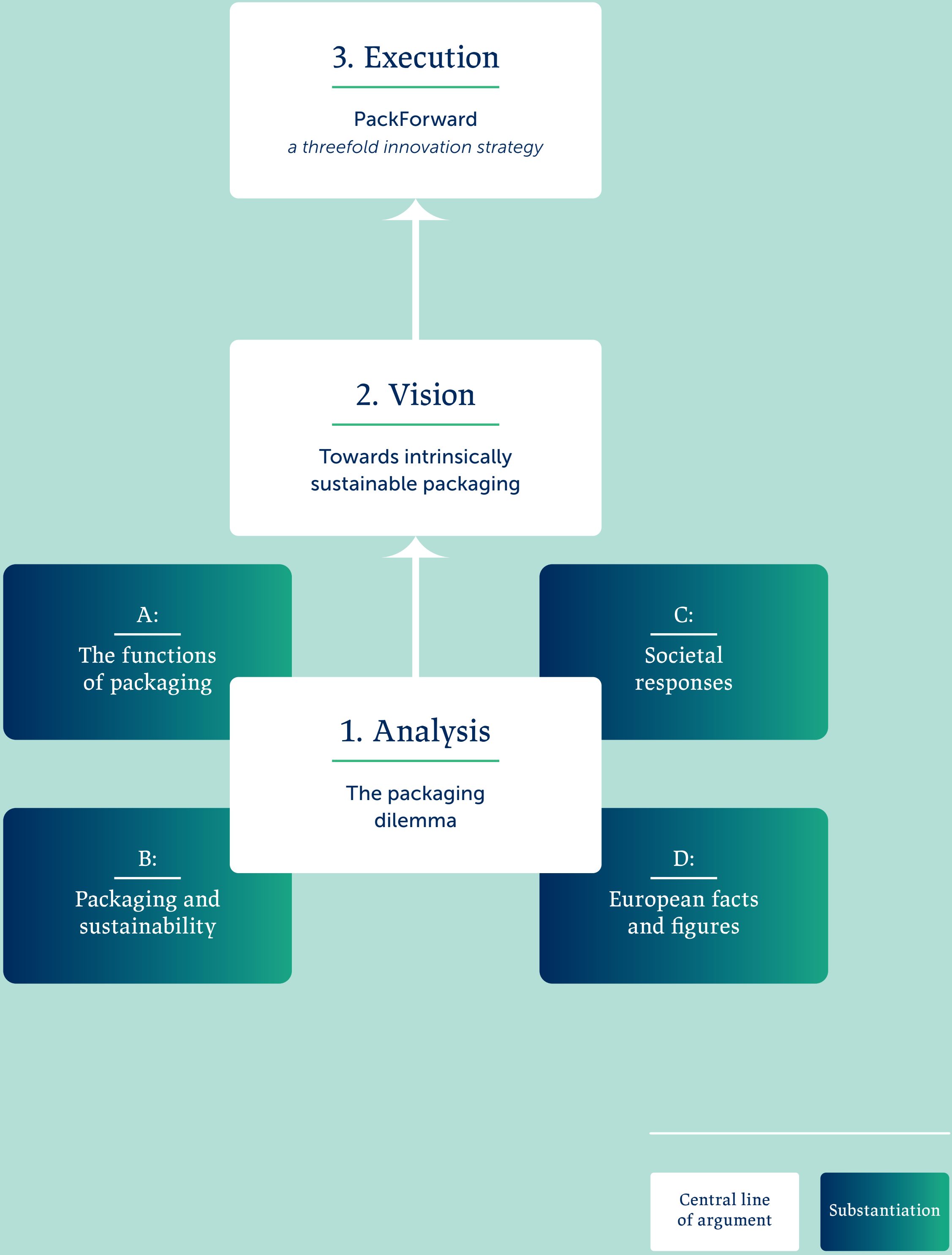


FIGURE 1 - SCHEMATIC OVERVIEW OF THE STRUCTURE OF THE STATE OF SUSTAINABLE PACKAGING.

Management summary

The core theme of this *State of Sustainable Packaging* is the sustainable packaging of food and non-food products. This publication describes both the functions and the problems of packaging. In addition and especially, it explores the question of how businesses, governments, social organisations (NGOs), knowledge institutions and citizens/consumers can effectively work on and contribute to sustainable packaging, both nationally and internationally.

The steps towards a circular economy and ultimately towards intrinsically sustainable packaging (packaging without any negative impact on mankind or the environment) are large ones. Taking these steps will require a strategic perspective on the necessary collaboration and innovations concerning sustainable packaging. That is why a wide range of partners contributed to *The State of Sustainable Packaging*. Many industrial partners are active in this field: a lot is already in process towards more sustainable packaging. Many examples will be shown in this publication.

We are specifically focusing on the role of plastics in this publication due to current discussions which centre around this material in particular. However, the main points of this publication are also applicable to other packaging materials.

Structure of the publication

Chapter 1 offers an analysis of packaging, with the focus on the packaging dilemma our society faces. Based on this analysis, a strategic vision is formulated in Chapter 2. Chapter 3 uses both analysis and vision to design the approach PackForward, which distinguishes between three parallel but soon coherent innovation tracks, being:

1) recycling
2) a circular economy
3) intrinsically sustainable packaging

The lines of discussion are supported in Chapters A, B, C and D of this publication:

A The functions of packaging in our modern society.

B The manner in which packaging products impact the environment.

C The manner in which different parties in society respond to the environmental impact of packaging, particularly in regards to the use of plastics.

D The facts and figures that illustrate to which extent the packaging issue manifests itself.

Brief overview of the basic principles of the lines of argument

Chapter A: The functions of packaging

Packaging products is both useful and necessary. Without it, the consumption needs of a large and growing global population can't be satisfied. The Autarchic Age is long gone: we - as individuals or as small groups - are no longer able to provide ourselves with food and other resources. Production has been centralised, while consumption has been decentralised. This leads to the need for packaging because products must be protected against spoilage and/or damage during storage and transport.

The functions of packaging include dividing and offering products in portions, preserving and protecting products, facilitating transport and distribution and providing information to users and consumers. In 2020 the average consumer uses seven packages per day. Of these packaging, measured in weight, 65% are used to package food products. Chapter A provides a detailed look at the use and necessity of packaging and the innovations that have been made throughout the years.

Chapter B: Packaging and sustainability

Packaging materials allow us to transport products further away and preserve them for a longer amount of time. By reducing its waste, the environmental impact of these products will be reduced. In general, however, it can be said that ninety percent of the overall environmental footprint can be attributed to the product and ten percent of the environmental footprint can be attributed to the packaging itself. Take food products, for example: food wastage as a result of spoilage is a much bigger problem than the environmental damage caused by the packaging, provided that the latter is responsibly processed after disposal. However, the global issues of plastic soup, and the possible issues of micro- and nanoplastics are of such a scale, that they justly underscore the question of how we can stop the pollution caused by plastic packaging.

In other words, both the packaging system and our production-consumption systems in their entirety pose major risks. Our consumption exceeds the boundaries of our planet. Packaging materials are part of the problem and can cause new environmental and health problems. There are plenty of - yet - unknown effects, like additives in packaging materials and the impact of micro- and nanoplastics on public health.

There is a growing understanding that we are not capable of fully closing the circle of our economy: as long as we hold on to our current methods of production and consumption and the packaging methods these require, our environment will inevitably continue to be contaminated. Recycling is no longer sufficient, forcing us to work on entirely new product-packaging combinations and system modifications that have no negative impact on the environment or public health. Doing so opens the road to intrinsically sustainable production, consumption and packaging.

Chapter C: Societal responses

Although the packaging issue has been around for decades, the response of civilians, NGOs and entrepreneurs to notable packaging problems such as litter and plastic soup has only become particularly notable over the past two years. Major initiatives were launched, such as those by the Ellen MacArthur Foundation, the Plastic Soup Foundation and the Ocean Clean Up. They all want to put a stop to the pollution of our environment by plastics. Their responses are mainly (but not exclusively) targeted towards "reducing and cleaning up the mess" and increasing the amount of recycling. Governments have responded in a similar manner, e.g. by curbing the use of single-use plastics and imposing higher recycling targets. Lastly, many businesses have joined in by formulating ambitious targets and voluntarily joining initiatives such as the Dutch and European Plastic Pact.

Chapter D: European facts and figures

Chapter D of *The State of Sustainable Packaging* provides various facts and figures that support the analysis. In this summary we present a selection of facts and figures. *Figure 2* illustrates how the packaging intensity has increased in recent years.

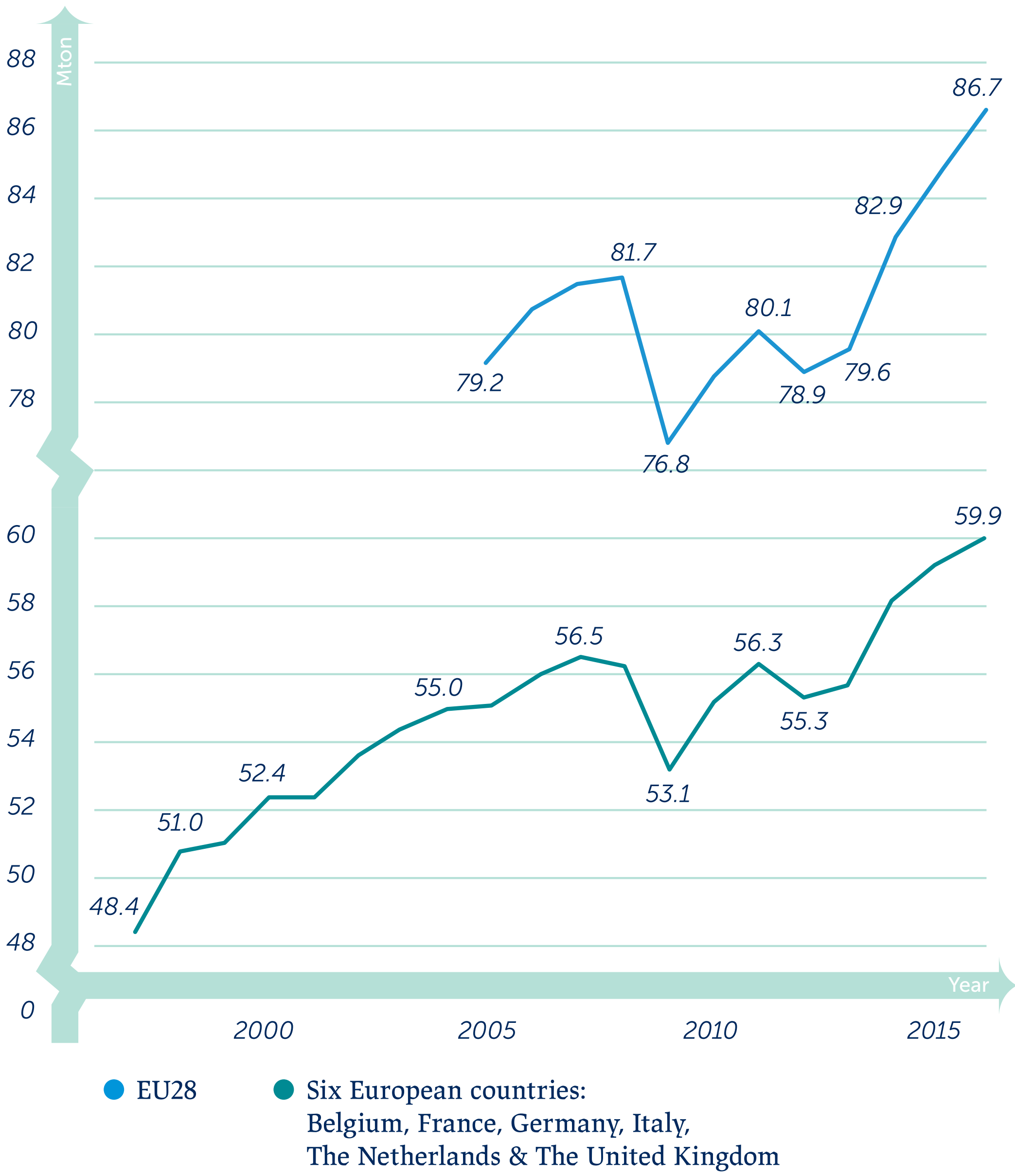


FIGURE 2 - THE TOTAL AMOUNT OF PACKAGING INTRODUCED TO THE MARKETS OF SIX MAJOR EUROPEAN COUNTRIES AND IN THE TOTAL OF EUROPE (MT/YEAR) [1]

The volume of plastic being used is increasing globally *(see Figure 3)*.

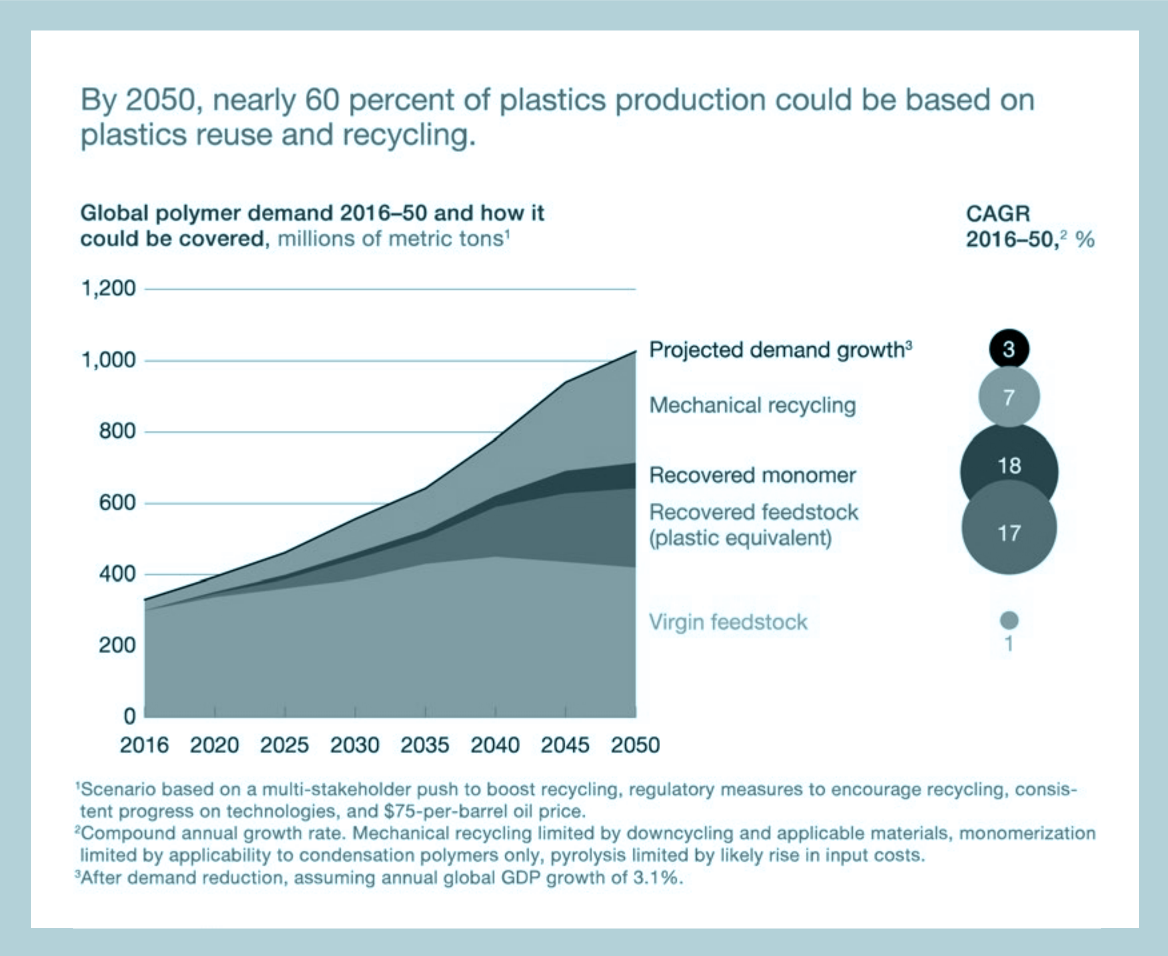


FIGURE 3 - GLOBAL POLYMER DEMAND 2016-2050 AND HOW IT COULD BE COVERED (ACCORDING TO MCKINSEY).[2]

Chapter D also contains figures about the recycling of packaging materials in the European Union. During the last decade, the recycling rates move upwards in most countries *(see Figure 4)*.

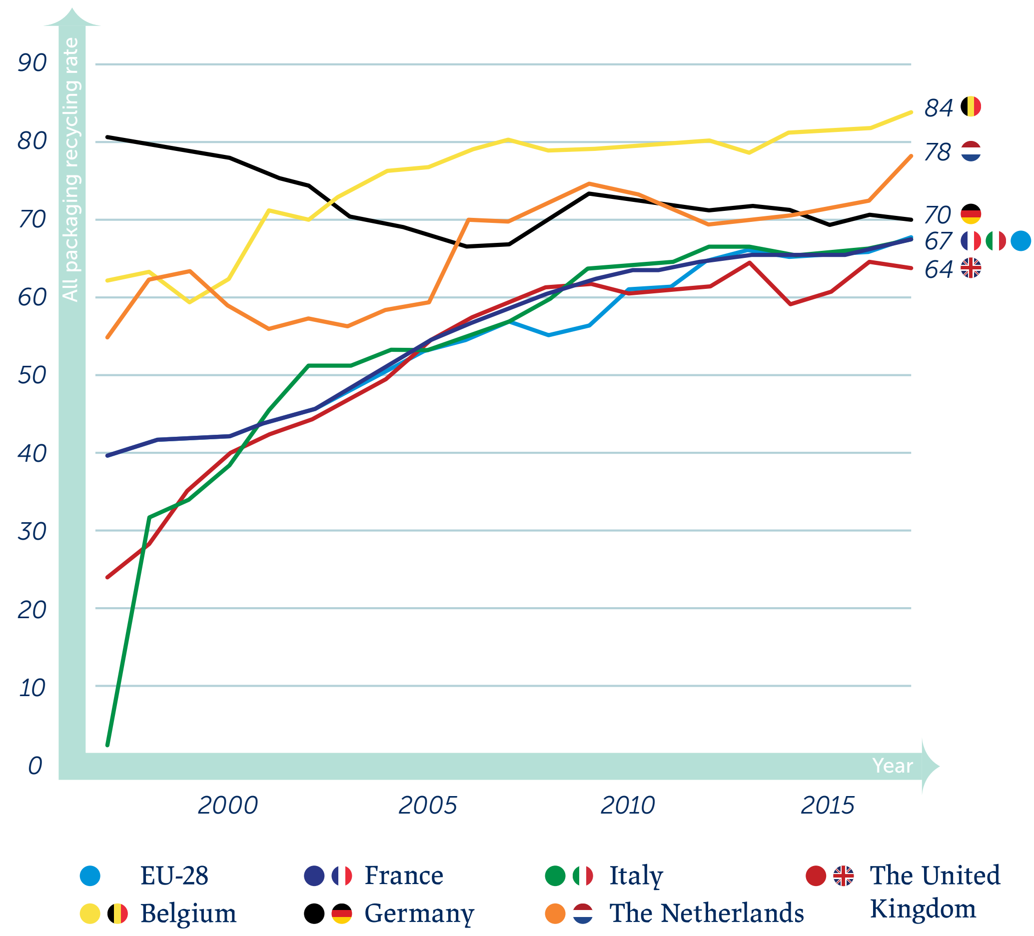


FIGURE 4 - PACKAGING RECYCLING RATE IN SIX EUROPEAN COUNTRIES AND THE AVERAGE OF THE 28 EU COUNTRIES OVER THE PERIOD 1997-2016[3]

Analysis, vision and approach

The four aforementioned chapters (A-D) support the central part of this publication: the analysis (Chapter 1), the vision (Chapter 2) and the proposed approach (Chapter 3) of this report. They are summarised below.

Analysis: The packaging dilemma (Chapter 1)

Chapters 1, 2 and 3 of *The State of Sustainable Packaging* have a strategic and societal angle: many parties therefore contributed to this publication. That is essential, because when it comes to solving the packaging problem, it is no longer justified to point the finger at only one of the involved parties (for example businesses, the government

or consumers), be it as the culprit or the proposed resolver of the issue. Instead, the approach requires close and concrete collaboration between all parties - ultimately on the societal scale - with innovation being the core concept.
The analysis illustrates that our society is currently facing a major packaging dilemma.

The packaging dilemma:

> *You cannot continue using current packaging methods, but you cannot abandon them either. After all, the intrinsically sustainable alternatives are not available yet.*

You cannot continue using current packaging methods, but you cannot abandon them either. After all, the intrinsically sustainable alternatives are not available yet.

Myriad reasons currently stand in the way of sustainable packaging. From a societal and economic perspective, these reasons are:

1. For a long time, packaging materials were a relatively minor concern or the final piece of the puzzle before putting a product on the market. It should be noted that there are differences between sectors. For cosmetics, for example, the packaging serves a far more important marketing function than for example Do-It-Yourself products.

2. The co-evolution of packaging materials and products makes sudden changes to packaging materials alone difficult to implement.

3. Requirements in regards to the marketing, sales, visibility and turnover rate of products are often at odds with sustainability concerns. Fortunately, we do see some changes in this regard: in more and more businesses, marketers opt for the sustainable alternative, even at the expense of their product's original appearance.

4. The innovation of the packaging for new retail (e-commerce) still lags behind this development, which often leads to overpackaging (such as the use of large outer boxes). The sector is gradually taking measures to resolve this issue.

5 Economy and convenience often beat austerity.

Several other reasons have to do with the existing plastic packaging materials and their recyclability:

6 Plastics are exceptionally versatile and flexible, making them hard to replace as packaging materials in terms of functionality. There is a gradual transition towards laminated paper and cardboard, which often represents a step in the wrong direction in regards to the objective of achieving higher recycling rates.

7 Recycling and circularity are ultimately not sufficient enough to resolve the packaging dilemma. Based on high yields for collection, sorting and recycling, the maximum yield of the entire recycling process is barely more than seventy percent. Even the higher yields of e.g. deposit schemes do not result in completely closing the chain.

8 Although business investments shape production processes in the long run, they are directed by short-term interim goals in the here and now. The interim goal of 100% recyclability by the year 2025 is at odds with the recycling yields that are actually feasible (see point 7).

9 In terms of both price and quality, the economy of recyclates and intrinsically sustainable solutions still loses out to the use of virgin materials from fossil resources. The adaptation of non-food packaging materials made from recyclate is still too limited (as a result of the colour, scent and appearance of the recyclate packaging).

10 The trend of lower packaging weights and dematerialisation impedes the economy of scale for recyclates, as is the case for e.g. light complex laminate packaging.

11 A wide range of different plastics and additives are being used. There is hardly any insight in the presence of potentially hazardous interferants in packaging materials and how these behave after recycling.

Lastly, the nature of the response affects the approach to the packaging dilemma:

12 The diverse and direct interest-dominated response from society is mounting.

13 In many cases, legislation precludes the use of recycled materials for food packaging.

As a result of the aforementioned reasons, there are no simple solutions to the packaging dilemma. The task that the parties in the packaging chain therefore face is to develop sustainable alternatives that professionally satisfy our packaging needs and entirely eliminate the negative environmental and health impact of packaging. Doing so will require change, renewal and innovation. As seen from the perspective of the existing production-consumption systems, this will involve the innovation of product-packaging combinations. We will, however, quickly run up against the complexity and rigid nature of our current production-consumption systems. These systems must therefore also be subject to the innovation process themselves. As of yet, there is insufficient awareness of the need for such a fundamental approach. People tend to be concerned about today. Short-term goals (2025), thus far, rake precedence.

Vision: Towards intrinsically sustainable packaging (Chapter 2)

Chapter 2 of *The State of Sustainable Packaging* starts by presenting three strategies by which the packaging problem has been, is being or can be tackled.

These three sustainability strategies for the packaging problem are:

1. *Laissez faire, laissez aller* (letting things be, passive approach); mainly utilised in the past.
2. *Problem-limiting* sustainable development (in response to excesses, reactive approach); mainly applied in the present.
3. *Intrinsically* sustainable development (preventing excesses, proactive approach); mainly required in the (near) future.

Until recently - let's say the fifties and sixties of the previous century - our economy was almost entirely linear: raw materials were extracted and waste was simply disposed of. In case it was economically beneficial or sensible to do so, packaging and materials were reused (think of e.g. glass or wooden crates). Environmental contamination was not that big of a problem yet, and thus there was no need to take action. People therefore had a passive attitude: *Laissez fair, laissez aller* ("strategy" 1).

However, the scope of the environmental problems kept increasing in regards to packaging materials, think of litter and plastic soup for example. People gradually came to their senses: it was clear that doing nothing is no longer an option. It was time to get the escalating problems under control. In response, society adopted strategy 2: Problem-limiting sustainable development. This strategy responds to excesses. Take the current recycling targets, for example: they are expanded again and again in response to the growing scope of the packaging problem. Adopting a stringent approach to recycling, expanded by adding other circular principles (like refurbishing and repurposing) into a fully circular economy, contributes a lot in resolving the packaging problem, compared to continuing with the earlier linear approach.

A lot can be gained with a problem-limiting approach. In general, however, a problem-limiting strategy will inhibit ongoing economic processes, which are still growing rapidly. It is therefore usually not met with great enthusiasm by stakeholders and rarely offers a quick and complete solution to the problem at hand. Furthermore, the limitation must be to such an extent that the problem *can* actually be resolved by it. But this hardly appears to be the case for e.g. micro- and nanoplastics.

That is why, from a societal perspective, a third strategy is preferable and even necessary: that of *intrinsically sustainable development*. This strategy is proactive by nature: it goes beyond limiting and keeping problems in check just as they occur. Instead, it proactively searches for sustainable ways to satisfy the needs and wishes of society. This proactive and future-oriented combination of developing opportunities and preventing problems is what makes this third variant of societal development *intrinsically* sustainable. It does not inhibit the economy; rather, it goes all-in on exploring new opportunities and possibilities. The material flows passing through our production-consumption systems will have to become biosphere-compatible. This allows our social welfare and well-being to grow even more.

These three sustainability strategies reflect our ongoing societal development. This societal development is represented in *Figure 5*. Starting in the distant past of small-scale operations and natural packaging systems (Autarky), we have now reached our Modern Age. An extensively economically optimised society that many billions of people take part in. Production and consumption are largely separated from each other in place and time. As a result, many products are basically available anywhere at any time, albeit in packaged form.

In the coming decade, we will transition from a linear economy to an economy that is as circular as possible. In a circular economy, materials are kept in the value chain as much and for as long and as high as possible via different cycles and in different ways. Ultimately, we will reach a Plurimodern Age in which we work on intrinsically sustainable product-packaging combinations in addition to the circularity that will already have been realised. This requires us to base our production-consumption-packaging processes on biosphere-compatible materials that do not negatively impact mankind or our environment.

Execution: PackForward, a threefold innovation strategy (Chapter 3)

Chapter 3 proposes a rigid approach to eliminating the packaging dilemma: **PackForward**. It is based on three interdependent innovation tracks that tie into our rapid ongoing societal development *(see also Figure 5)*. Efficiency is a core aspect of all three innovation tracks, although each is named after its respective key characteristic:

Innovation track 1:	**Recycling** (in progress).
Innovation track 2:	**Circularity** (introduction of additional loops in the production-consumption systems of the circular economy).
Innovation track 3:	**Intrinsic sustainability** (development of non-polluting and biosphere-compatible economic systems).

In terms of the sustainability strategies from Chapter 2, innovation tracks 1 and 2 are centred around problem-limiting strategies. Innovation track 3 offers a definitive solution to the packaging dilemma by developing intrinsically sustainable solutions based on societal innovation.

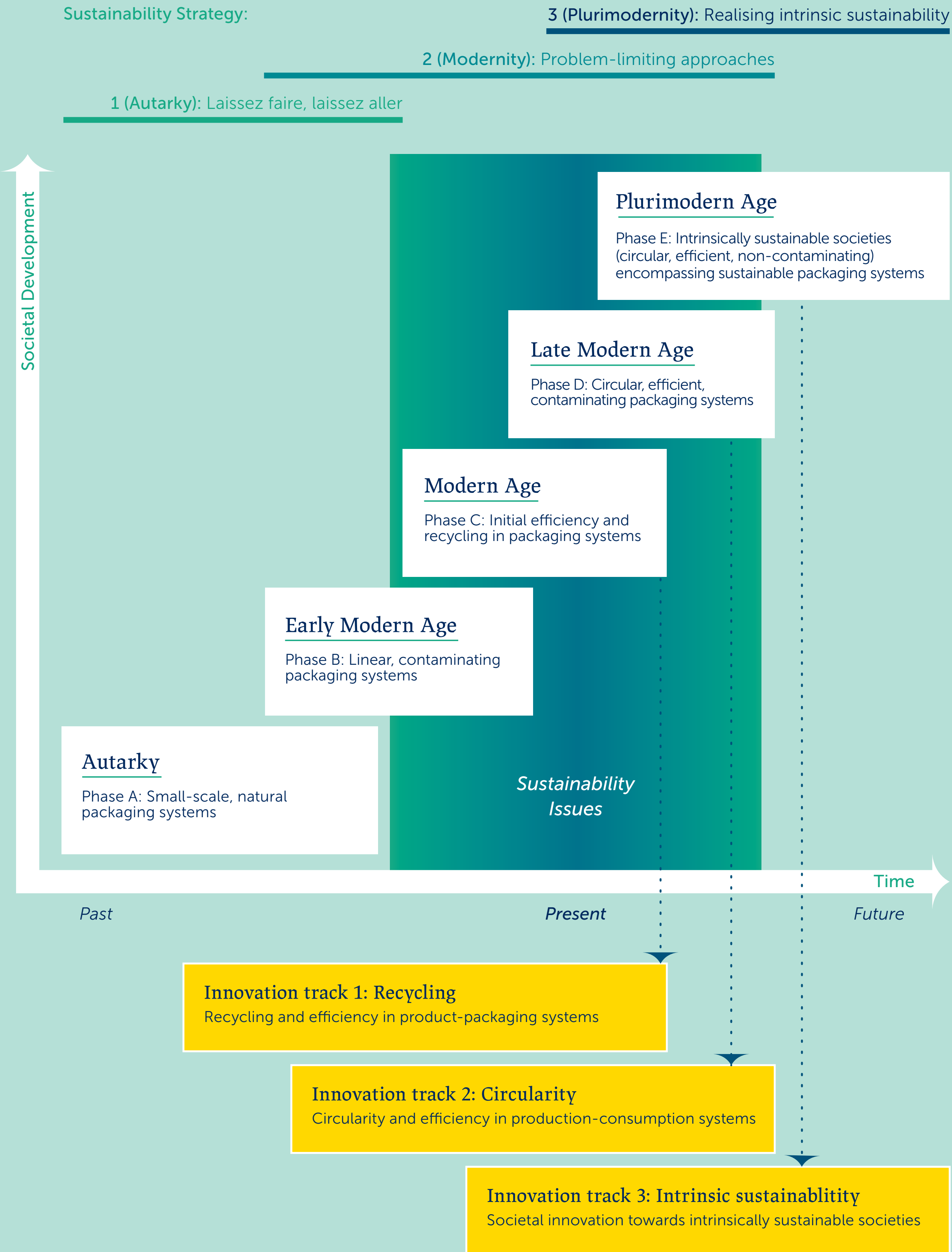


FIGURE 5 - SOCIETAL DEVELOPMENT, SUSTAINABILITY STRATEGIES AND INNOVATION TRACKS IN TIME.

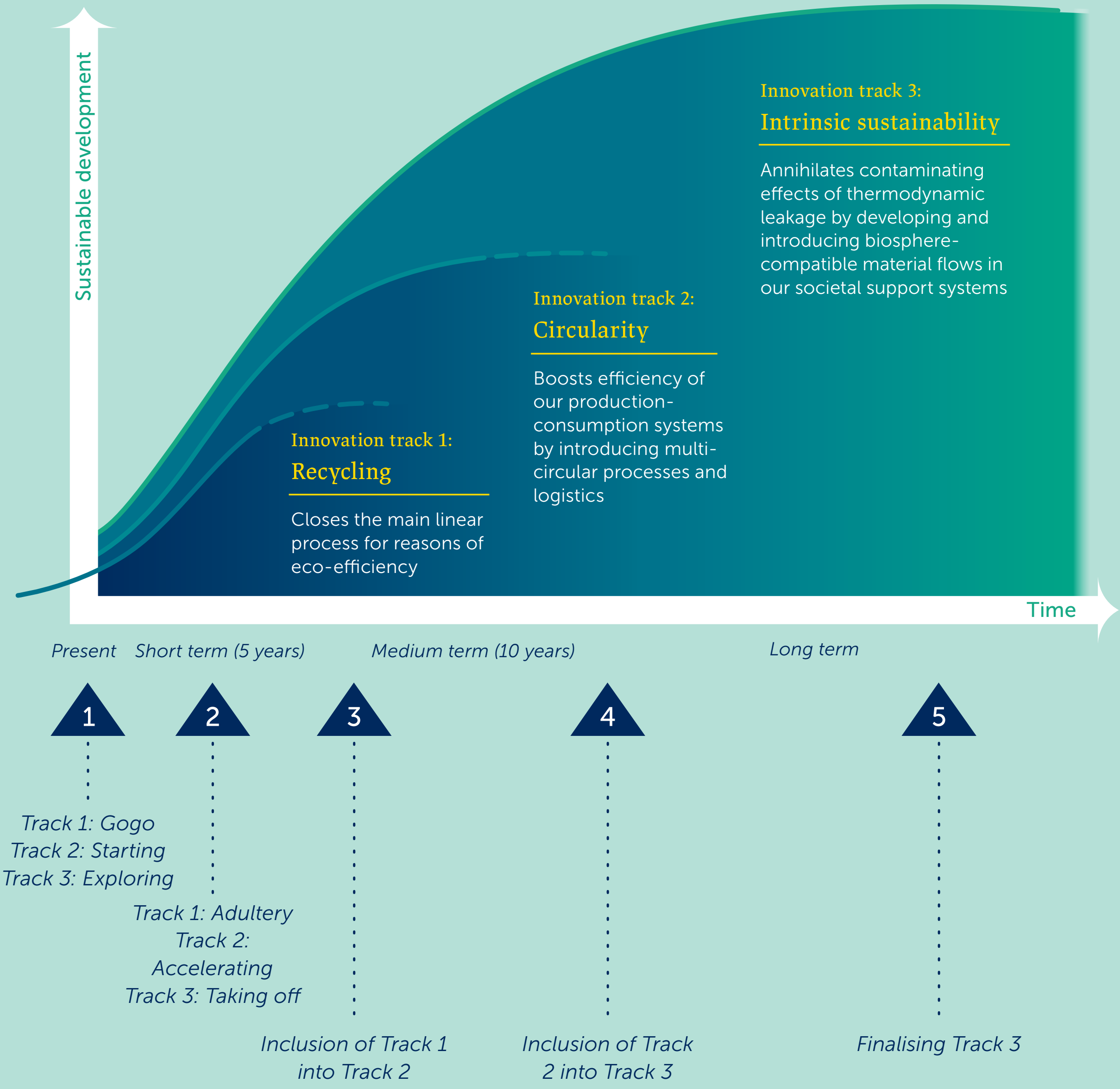


FIGURE 6 - THE THREE INTERCONNECTED INNOVATION TRACKS, THEIR POSITIONING IN TIME AND THE EXTENT OF THEIR SUSTAINABILITY (ILLUSTRATIVE).

The three tracks start parallel to each other but will become intimately interconnected, each of them peaking at a different moment in time *(see also Figure 6)*. Upon a transition of dominance, subsequent dominating tracks will include the key characteristics of earlier dominating tracks, thereby making these former tracks obsolete as stand-alone tracks. Innovation track 1 is about product-packaging combinations. The focus is on recycling and the efficiency of packaging materials. Innovation track 2 expands that focus to include integral production-consumption systems and introduces a wide range of circular principles (like reusing and refurbishing). Recycling, the dominant value of innovation track 1, continues to be an integral aspect of track 2, as is efficiency. Lastly, innovation track 3 looks at our societal practices as a whole and focusses on innovating and improving at the higher levels and scales necessary in order to realise intrinsic sustainability. This requires the development and use of biosphere-compatible materials. The scope and goals of innovation tracks 1 and 2 are integral aspects of innovation track 3.

Each of the three innovation tracks is characterised by a different culture, a different playing field and different combinations of innovation methods. The different tracks are briefly described below:

Innovation track 1:

Recycling and efficiency in product packaging systems, with a focus on the short term. This track is characterised by far-reaching recycling and efficiency in the here and now and it is already running at full speed in leading countries. This track is the primary responsibility of producers, importers, recyclers and packaging specialists (product responsibility). This innovation track is about e.g. improvements to waste collection systems for source separation, the utilisation of post separation, sorting packaging waste into streams of mono-materials, improvements to recycling and improvements to the recyclability of packaging made by producers and importers of packaged products and producers of packaging materials.

Innovation track 2:

Circularity and efficiency in production-consumption systems, peaks at the short to medium term. The target system in track 2 is the complete production-consumption system, which will offer many more possibilities to close circles than merely the recycling of waste at the end. It improves efficiency by introducing multi-circular processes and logistics based around principles such as reuse, repair and refurbish. The goal is to realise a fully circular economy. Circularity is already part of the strategies currently employed throughout Europe, but the time has come to intensify and ramp up our efforts from pilots to upscaling. Solutions from track 1 must tie to track 2.

The innovations in track 2 call for the involvement of additional stakeholders. The primary playing field of this track will expand until it incorporates all actors involved in (the transition of linear systems into) multi-circular systems. Producers and importers will remain key players, although they will no longer be able to direct the innovation processes in relative isolation. After all, the innovations from track 2 involve complex return logistics via various loops. The changes influence and affect the methods and behaviour of retailers, logistic actors, consumers, recyclers, refurbishers and many others. Compared to track 1, this will drastically alter the culture of the process and the innovation methods that are utilised. For example, track 2 requires excellent skills with regard to multi-actor process management, as well as knowledge of culture, behaviour and logistics.

Innovation track 3:

Intrinsic sustainability focuses on societal innovation towards intrinsically sustainable societies. Its operational effects take place over years and even decades. This is the most ambitious of the three tracks. It questions the finite nature and depletion of natural resources, as well as the bio-incompatibility and polluting nature of the material streams that circulate in the production-consumption systems of tracks 1 and 2. These material streams must change into biosphere-compatible and non-polluting streams. This crucial and challenging step will ultimately result in the definitive solution to the packaging dilemma that is so urgently needed. It will enable us to subtitute current, unsustainable modes of packaging by newly innovated intrinsically sustainable modes. We will continue packaging while discarding unsustainable modes of the past.

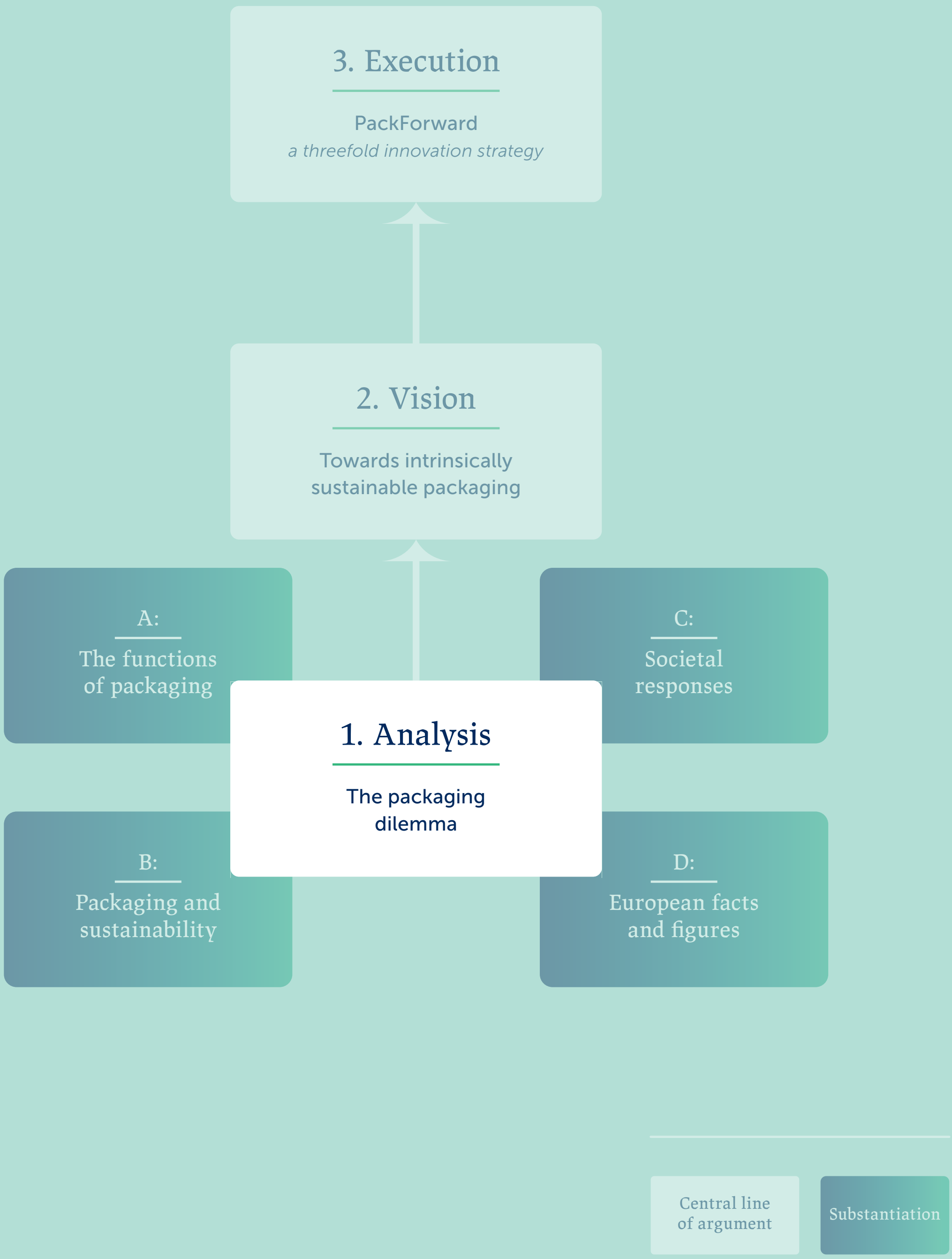
At first, it will demand the use of pioneering and ground-breaking innovation methods; only later will it require optimising innovation methods. This manner of innovation is incompatible with the “going concern” in business. Instead, it requires a strong focus on the future and a societal task force — consisting of entrepreneurs, researchers, government officials and citizen-consumers — that is specifically dedicated to and equipped for this task.

At the moment, it is unclear what kind of societal innovations and exact changes to material streams and technologies track 3 will bring about and require. The future is hard to predict. Nevertheless, our transition to intrinsically sustainable societies is inevitable, given the growth and development of both the economy itself and the number of individuals who take full advantage of its many benefits. That is why it is important to go all-in with this innovation track 3 as soon as possible, on top of innovation tracks 1 and 2.

Acting together on three interconnected tracks

It is important to make rapid progress on all three innovation tracks, both separately and together: although they are different, they form a “package deal”. It is therefore necessary to maximally intensify and coordinate the efforts on Innovation track 1: Recycling and expedite and further develop the efforts on Innovation track 2: Circularity. In addition, Innovation track 3: Intrinsic sustainability must be instigated immediately and ramped up quickly.

All this leads to one single recommendation that is as simple as it is ambitious. Intrinsic sustainability is a *conditio sine qua non* for our future. The proposal is therefore to initiate the three-track innovation strategy in a structural manner as quickly as possible, utilising the many relevant insights and activities that are already in place. This is important because our future needs to be intrinsically sustainable. Our packaging systems will be an integral part of this.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Chapter

1

Analysis:

The packaging dilemma

Packaging materials are both useful and necessary. At the same time, they are the subject of a lot of societal discussions. This first chapter will, therefore, offer a closer look at and an analysis of the packaging problem. Where do we stand and what is actually going on?

1.1 What is going on?

The world of packaging is changing. Packaging is an enabler of our modern society with many benefits. At the same time, civilians, NGOs and entrepreneurs are expressing their concern about notable packaging problems such as litter and plastic soup polluting the oceans. Then there are the health issues, such as those that arise from the use of additives. Today, micro- and nanoplastics are found in almost every part of our biosphere, which means they are also making their way into the food chain. The WHO has urged to put a stop to this development.[4] The outcry in the media is becoming bigger. Governments are taking the growing unrest in the society at large seriously and translate it into new policies. It is clear that serious measures are needed. Fortunately, this work has - tentatively - begun.

1.2 Environment and economy

Simply put, the packaging dilemma falls under the classical environment-economy division.[a] Businesses are said to cause problems and focus primarily on economy. In this view, citizens are seen as the victims. Backed by NGOs, they ask for a healthy and clean environment. The government responds to societal unrest and the media and does its best to weigh the various stakeholders' interests. In doing so, it must take the economy into account on the one hand and the environment and public health on the other.

Nevertheless, this classical, somewhat schematic division between economy and environment insufficiently accounts for the fact that packaging is an essential and fundamental aspect of our production-consumption systems. They form the essential support systems for the late-modern society we live in. Our modern network society divides the production and consumption of food and non-food products into time (a.o. shelf life) and space (transport). We all enjoy the benefits of this far-reaching specialisation. We are no longer forced to provide for our own food, tools and products and the quality and variety on offer are impressive. To that end, our production-consumption systems do require a professional packaging system, which is precisely what we developed and allowed to evolve over time. This system largely - though not exclusively - relies on the use of plastics. However, this packaging system is increasingly plagued by serious environmental, health-related and societal problems.

[a] A NOW CLASSICAL SUSTAINABILITY DIVISION IS BASED ON THREE PILLARS: PEOPLE, PLANET AND PROFIT. SEE FOR EXAMPLE ELKINGTON, J. (1998). THIS DIVISION DISTINGUISHES BETWEEN DIFFERENT INTERESTS, BUT ALSO PLACES THEM OPPOSITE EACH OTHER. IN DOING SO, IT MAY OBSCURE THE FACT THAT SUSTAINABILITY IS A PROBLEM THAT AFFECTS ALL OF SOCIETY AND THAT WE MUST TRANSCEND THIS THREEFOLD DIVISION IN ORDER TO RESOLVE THE ISSUE.[5]

Every citizen makes economic decisions as a consumer and *every* entrepreneur benefits from a healthy and clean environment. Especially in a democracy, one could argue that the government represents all of us. This report goes beyond the classical division and deliberately opts to present the packaging problem as a *societal* issue. The focus is specifically on the fundamental *packaging dilemma* that our society currently faces and on how to resolve it. We can no longer get away with simply pointing the finger at someone else.

1.3 The packaging dilemma

A modern society depends on complex production-consumption systems. These support systems are *a sine qua non* for sharing one planet between billions of people and require a professional packaging system. However, despite the myriad benefits it offers, that same packaging is now starting to cause serious problems, which also affect our entire production-consumption systems. Their impact exceeds our planetary boundaries (see Chapter B) and - if our policies do not change - will break down the very foundations of our society: a clean, healthy and safe environment.

The packaging dilemma can therefore be summarised as follows:

> *You cannot continue using current packaging methods, but you cannot abandon them either. After all, the intrinsically sustainable alternatives are not available yet.*

You cannot continue using current packaging methods, but you cannot abandon them either. After all, the intrinsically sustainable alternatives are not available yet.

1.4 Dilemma? Why not solve it!

Something has to change - and quickly. Everyone understands that much. Dilemmas are generally resolved by transcending the thinking that suits the available choices. You design a solution by thinking in a way that basically eliminates the impossible choice before. However, dilemmas tend to resist new and simple solutions. The same goes for the packaging dilemma.

One way to come up with a solution is by flipping a dilemma on its head. In this case, that gives you: "You can continue to use the same packaging methods and you can abandon them."

There are proponents of *abandonment*. Whenever it is easily possible to do so, one should indeed stop using packaging materials altogether. However, it is important to remember that packaging materials are used for a reason and that they have multiple functions. These are explored in more detail in Chapter A. In individual cases, it is certainly possible to argue about the usefulness and necessity of packaging materials. In most cases, however, you will either have to replace the functions in question or make them redundant. Simply abandoning current packaging methods is a woefully inadequate solution in this day and age.

When it comes to *continuing on the same path*, you will have to develop the sustainable alternative. It is important to fundamentally avoid the negative consequences of packaging. That requires change and innovation. With regard to the existing production-consumption systems, problematic packaging materials must be replaced by unproblematic packaging materials. This requires the innovation of packaging materials and product-packaging combinations. But by doing so, you will run into the limits of our current production-consumption systems. For a more societally innovative perspective, you must make the systems themselves part of the innovation process as well. The production-consumption systems must be set up in such a way that the mounting negative impact of packaging materials and waste streams will be eliminated.

In theory at least a rigid societal innovation course with regard to our production-consumption-packaging systems offers a promising course towards a complete solution. That will require some effort, however. The packaging system is resistant to changes towards improved sustainability. There is a complex web of reasons for this, that ties into how our societies developed in the past and function in the present. These reasons go far beyond any supposed unwillingness or indifference.

A number of reasons for this resistance is outlined below. There is significant overlap in most cases. This analysis preludes to the chapters to follow and is not intended to be comprehensive.

From a societal and economic standpoint, our packaging methods are deeply embedded and rooted in our society:

1. *For a long time, packaging materials were a relatively minor concern or the final piece of the puzzle before putting a product on the market*. It should be noted, though, that there are differences between sectors. For cosmetics, for example, the packaging serves a far more important marketing function than for e.g. Do-It-Yourself products. Traditionally, the cost share of packaging materials is much smaller than the cost share of product waste and loss without packaging. Similarly, the environmental impact of packaging was traditionally much lower than that of product loss.[6] We are now at a point where packaging materials (as part of plastic soup, micro- and nanoplastics) are found in all parts of our biosphere.[7] Having packaging materials be an important point of attention from an environmental and health perspective is a relatively new state of affairs.

"Despite a number of advantages of plastics, the disadvantages dominate the societal discussion, such as the alarming effects of microplastics in the environment. Industry plays a major role to change the course and come up with sustainable solutions."

Prof. Jacqueline Cramer,
Chair of the Committee of Independent Experts at KIDV,
The Netherlands

2. *The co-evolution of products and packaging materials makes sudden changes difficult to implement*. Combinations of products and packaging materials are usually the result of a lengthy process of co-development and co-evolution. In this regard, history matters. Past requirements with regard to marketing, transport, shelf life and usage are deeply embedded in current product-packaging combinations. Take, for example, the packaging of a television where the packageability and transport requirements dictate the rigidity of the packaging and vice versa, or dishwasher tablets where the method of use by consumers is embedded within the packaging itself.

3. *The marketing, sales, visibility and turnover rate of products impose requirements on packaging materials that are now at odds with sustainability*. In a society organised around competition and economic considerations, entrepreneurs

cannot simply ignore such aspects. This leads to additional packaging pressure, to which current packaging methods are perfectly tailored. Change therefore requires fundamental (societal and technological) innovations.

4 *Innovation in retail channels and consumption patterns is still not packaging inclusive enough*. Look at e-commerce, home deliveries by supermarkets, single portions and just-in-time deliveries to consumers, for example. Oftentimes, sustainable packaging is not taken into account when implementing such convenience-oriented, and other innovations, despite there being opportunities to do so. Instead, existing (and outdated) packaging technologies are used.

5 *Convenience generally wins from austerity*. Our current methods of packaging, production and consumption offer tremendous benefits from the perspective of consumers. It is hard to imagine people willingly, structurally and abruptly giving up these short-term convenience benefits in exchange for a far more austere lifestyle to gain long-term environmental benefits. In this case, the consumer in us generally wins from the citizen in us.

"Consumers like more sustainable choices. No question about that. But consumers are still attracted to products first and foremost by how affordable they are, how well they perform and how beautiful the design is."

Tom Szaky,
CEO at TerraCycle,
United States

Then there are several reasons for the existing packaging materials and their recyclability:

6 *In terms of functionality, plastics are ideal packaging materials*. From a strictly functional perspective, plastics offer excellent and exceptionally flexible features (see Chapter A). In comparative environmental studies (LCAs, life cycle analyses), plastic packaging materials do not perform nearly as poorly in comparison with current alternatives as is generally believed. In fact, they often perform better (see also Chapter B). However, the problematic aspects of plastics are becoming increasingly severe and a rigid approach is needed to resolve these issues. But possible alternatives are – at the moment – not yet clear and certainly not available and applicable on a large scale.

7 *Improving the recyclability and circularity of our current packaging waste and waste streams alleviates the problems, but a complete solution calls for societal innovation that results in intrinsically sustainable solutions*. Recycling and circularity significantly limits the packaging and waste streams that end up in our biosphere. These concepts can be applied to current basic technologies and materials, which offers a major benefit that will allow us to continue using the current plastics. However, this does not offer a long-term structural solution to the problem at hand. There will inevitable be some leakage, since completely closing the chain is impossible for thermodynamic and practical reasons (see also Chapter 2). If we assume high yields of 80% for collection, sorting and recycling, the maximum yield of the entire recycling process is only slightly more than (0.8^3) which equals some 50%, *(see also Figure 10)*. Even the higher yields of e.g. deposit schemes do not result in the complete closing of the chain. Persistent contaminating substances will continue to spread and gradually stack up in our biosphere.[8] The ultimate solution therefore calls for material streams in our production-consumption processes that, after the inevitable leakage, do not cause any environmental or health issues. The transition to such a biosphere-compatible system, in which recycling and circularity continue to be core components, requires significant technological and societal innovations.

8 *Although business investments often shape production processes in the long run, currently they are directed by short-term interim goals (2025: recycling and circularity)*. As a result, the assets are fully dedicated to developments that - although certainly helpful - are not necessarily intrinsically sustainable. If there were a clear long-term path of direction, it would help businesses make more sustainable investment decisions. Short-term strategies could lead to divestments partly because e.g. packaging machines have a lifespan of about fifteen years.

9 *The economy of recyclates and intrinsically sustainable solutions is still losing - by a wide margin - of virgin raw materials and non-sustainable solutions*. Subsidies and government support are still largely spent on technologies of the past which only reap the rewards of their maturity, but don't contribute to a sustainable future. A society organised around a short-term economy and extrapolation, hinders expedited societal innovation and upscaling towards intrinsic sustainability.

"There are always lots of questions about source and post-separation, about plastics and about food safety. As far as I know these questions never have a 100% correct answer. But shouldn't we be able to find a way in which all of Europe can roughly agree?"

Diederik Samsom,
Head of Cabinet of Executive Vice-President Frans Timmermans at the European Commission

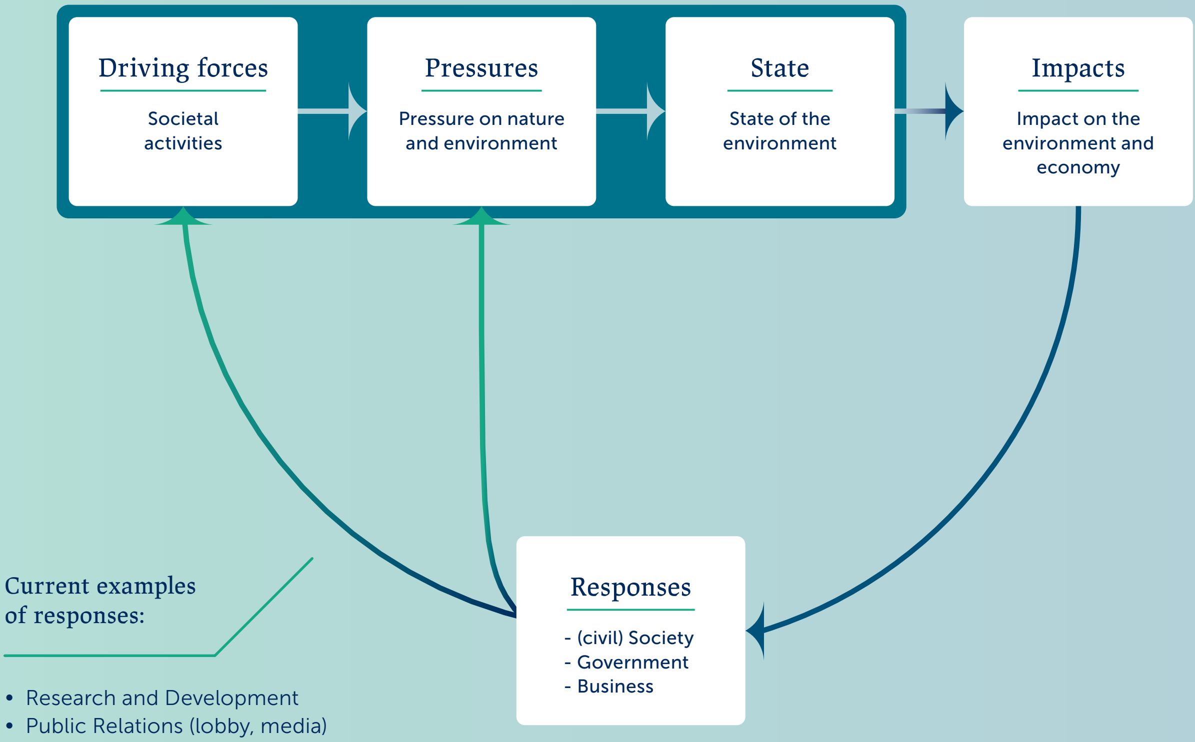
10 *The trend of lightweighting and dematerialisation impedes the economy of scale for recyclates.* Because packaging materials are becoming thinner and lighter, the available economic gains of the return streams diminish as well. Restricting the number of variants might possibly help here.

Lastly, the diversity of the response from society and the government complicates a clear approach to the dilemma. The cause of this response is clearly described by the DPSIR model (Driving Forces, Pressures, State, Impacts, Responses) *(see Box 1)*. This response can be outlined as follows:

11 *The response from society is indicative of growing tensions, yet said response is diverse and affected by various long- and short-term interests.* Unrest amongst society is growing and gets more and more attention from and thus coverage by the media.The response is diverse: NGOs and the environmental movement adopt clear positions, businesses understandably point to the context in which they have to operate and its limitations, the vast majority of consumers continues to buy products on an unprecedented scale and worried citizens look to the government for help. The government has to balance myriad interconnected interests, which is no easy task.

Box 1: Short introduction DPSIR model

The DPSIR model is a well-known analytical framework from environmental science that shows how increasing environmental problems can prompt public and political responses in order to address the underlying causes or mitigate their consequences. It consists of the following elements (*see Figure 7*, adapted from PBL[9]), explained in Chapter B.



- Research and Development
- Public Relations (lobby, media)
- Extended Producer Responsibility
- Commitment to goals (pledges)
- Policy and legislation
- Court ruling

FIGURE 7 - DPSIR MODEL.

"Defending our choice for plastics to the public is tough. The perception of plastics is hard to break through. We get a lot of questions and we have to clearly explain that it is better to package products in plastic when this significantly improves the life span of these products and prevents final waste."

Henk van Harn,
Director Preservable and Non-Food at Albert Heijn,
The Netherlands

12 *In many cases, legislation prescribes that recycled materials cannot be used for the production of food-grade packaging materials*. Currently the European Union accepts rPET as a possible material for food packaging under strict conditions. In almost all other cases plastic food packaging must be made of virgin materials which have to be tested with five simulants for migratory levels according food safety legislation (EC 1935/2004). It is evident that applying recycled plastics in food packaging is a very complex route to circularity from a material and technological point of view.

1.5 What does this mean for the strategy?

The packaging dilemma requires a structural solution. It cannot be seen separately from the environmental and health issues that plague our production-consumption systems as a whole. As the packaging dilemma states, we can neither stop what we are doing nor continue doing it. What we can do is opt for a course of action of ongoing societal innovation; an innovation that not only curbs and minimises environmental and health problems, but also prevents them and capitalises on entirely new opportunities.

This path of innovation is not an easy one to walk. It is inhibited by significant and large-scale societal path dependency. Think of the proverbial supertanker: a rigid course change is needed, but the tanker's speed and size make this a tricky business. It is difficult to chart the desired course and the port of destination is shrouded in mist, although we know that it must be free of environmental and health problems.

The crew on board will dread the uncertainties, the efforts and the costs involved. Especially how these will be divided amongst them. These sacrifices are all insignificant in the long run, but as economist John Maynard Keynes aptly put it: *"In the long run we are all dead"*.[10] It is hard to put in an effort without seeing or benefiting from the immediate result. Despite this, we must get to work resolving the issues at hand and divide the workload fairly and evenly.

All in all, there is a complex, sometimes even confusing and opportunistic playing field regarding packaging materials and waste. When it comes to implementing a rigid solution to the waste and packaging dilemma, changing our course will require sacrifices. We can no longer get away with simply pointing our finger at others. As a society, we have caused our production-consumption systems to be in the condition they are in now. As societal partners, we will now have to work together to take the necessary steps to bring about the next and intrinsically sustainable condition. That is not always easy with parties having different perspectives on the nature, urgency and ownership of problems and the direction and speed of solutions. Nevertheless, many businesses, citizens, consumers and governments are well on their way.

Businesses have a strong need for clarity about where things are headed, level playing fields and a fair division of costs and benefits. Confronted with the packaging dilemma, many businesses prefer gradual improvements to more structural solutions (due to the aforementioned path dependency and lock-in). That makes sense: small steps are easier to oversee and when you take structural leaps, it is not always clear where you'll end up. Then there is the fact that different countries and blocks employ different regulations and practices, which inhibits large-scale investments. Still, small steps alone are no longer enough. The necessary changes are ultimately too great for that (it is time for substantial and even large innovations).

Citizens want to be freed from the negative impact of packaging materials. However, as consumers, they are the cause of this issue due to high levels of consumerism and the heavy use of packaging materials because of their love for comfort, choice and convenience.

Governments are responsible for preventing social problems (environment and health). Policies are based on the societal response to the packaging problem, which is diverse. At the moment, governments respond by imposing recycling targets on businesses. This is done in an attempt to implement a short-term solution to curb the most high-profile waste scandals (litter, plastic soup). That makes sense from their point of view, since it is what citizens and the media call for.

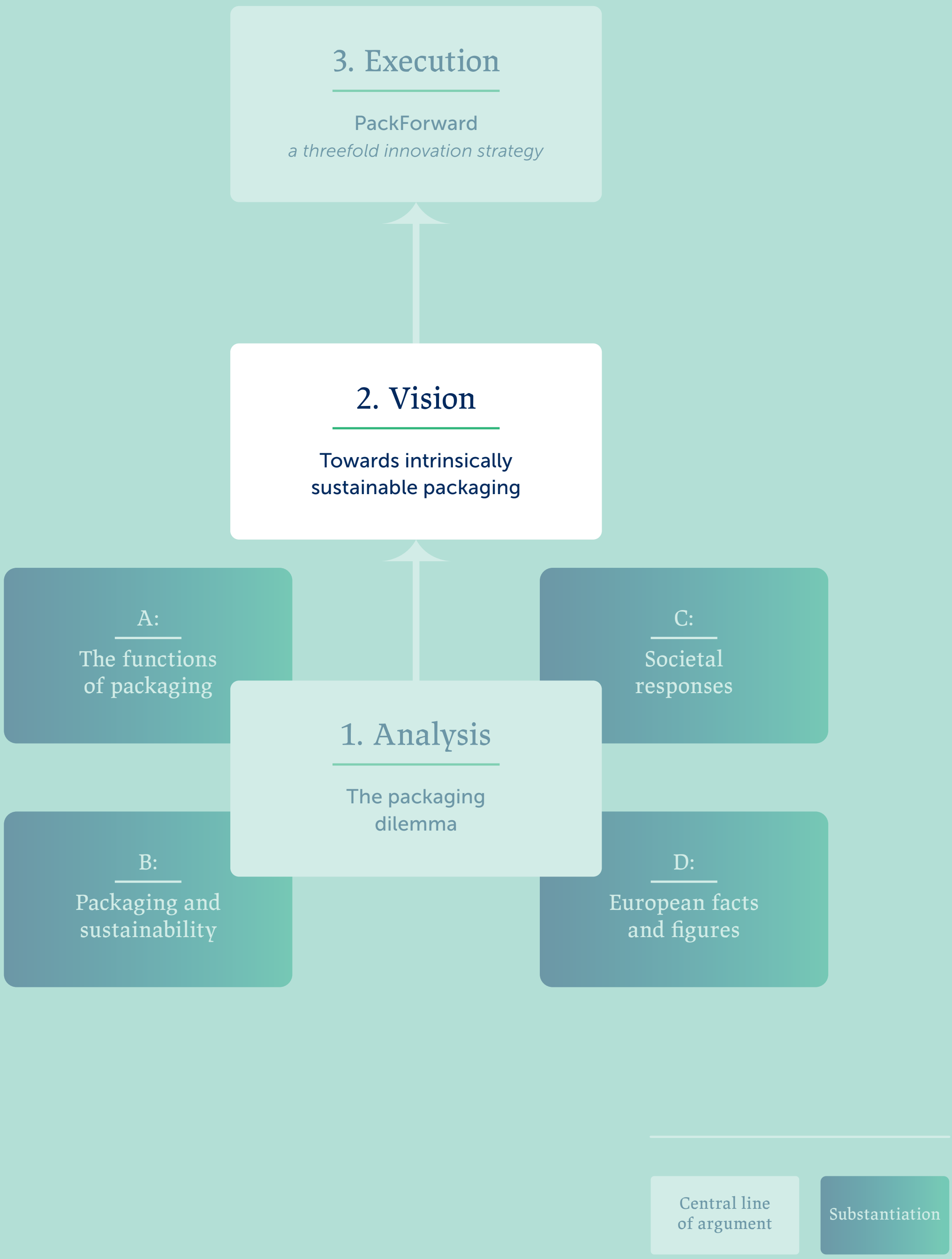
How can all this be brought together? How can we make sure that we do not stray from our old path before we have charted a new course? Or, to put it differently: how can we avoid spending all our time mopping the floor while the tap is running?

1.6 What will it take?

As a start, we must develop an overall strategic vision on the packaging problem. This vision must tackle the central dilemma at its core and account for the aforementioned unruly problems that hinder taking a societal course of innovation. It must also outline the concrete steps, along with names and responsibilities, despite the vast scope of the innovation challenge that lies ahead.

This analysis and Chapters A-D offer a springboard for the development of such a strategic vision. This vision is presented in Chapter 2: *Towards intrinsically sustainable packaging*. The basic principle is that the packaging dilemma is a societal issue, which therefore calls for a radical solution that is implemented in close collaboration between all parties. The contributions from different angles, as described in Chapters A-D, are gratefully utilised.

Subsequently a vision alone offers no concrete solution to the problem. It must be translated into something practical and manageable. Chapter 3 therefore presents an implementation strategy: *PackForward*. The underlying execution plan consists of three interconnected and overlapping innovation paths, each briefly described.



3. Execution
PackForward
a threefold innovation strategy
2. Vision
Towards intrinsically sustainable packaging
A:
The functions of packaging
C:
Societal responses
1. Analysis
The packaging dilemma
B:
Packaging and sustainability
D:
European facts and figures
Central line of argument
Substantiation

Chapter

2

Vision:

Towards intrinsically sustainable packaging

2.1 From responsive to proactive

As we have seen, there are two sides to packaging. Economically speaking, professional packaging is foundational to modern-day prosperity, allowing for far-reaching separation and functional differentiation of production and consumption. From a social point of view, packaging is at the basis of increasingly severe environmental and health problems. This is true for Western countries, but even more so in emerging economies with poor processing infrastructures for packaging.

The DPSIR model (see Chapter 1) explains how increasing environmental problems prompt public and political responses in order to address the underlying causes or mitigate the consequences. In the light of these social and political dynamics, the debate on packaging can be understood as follows: there is a growing concern in society about the impact of our actions on nature, health and environment, as expressed by various groups, which forms the basis for a response. This reactive process is very understandable, and these expressions of concern are taken seriously by governments and companies. The question, however, is whether solely responding to the expressions of concern that receive the most attention, offers sufficient prospects for sustainable modes of packaging. Preferably, we should take a more proactive approach by not only responding to the loudest protest, but also by taking forward-looking, innovative, design-based steps towards intrinsically sustainable solutions ourselves. This chapter sets out a strategical vision, adopting these considerations, in further detail. In Chapter 3 the issue will be addressed on how to execute such a strategic vision.

2.2 Towards intrinsically sustainable packaging

We cannot stop, but also cannot continue our course (see the dilemma in Chapter 1). In general, dilemmas like this may be solved by choosing a vantage point that transcends the two equally undesirable choices. Looking at the matter from a broader perspective, may help in identifying new and advantageous courses of action in which the deadlock, resulting from the two prongs of the dilemma, no longer applies. In the packaging case, continuing our path will inevitably result in a harsh clash between economy and environment, a clash that is starting to unfold rapidly at this very moment. So why not develop in such a way that our economy on one hand and our environment and health on the other, are not enemies anymore, but rather support each other and function symbiotically? The goal is to strike a mutually supportive balance between our economic processes and the processing capacities of our biosphere.

This course of action we coin *intrinsically sustainable development*. It is different from the dominant, reactive mode of sustainable development that we are pursuing at this very moment. Our dominant strategy is directed at managing problems by trying to limit and contain them. A development that doesn't solve the dilemma and prevent the clash in the long run, as we will see further on. To attain an intrinsically sustainable future, we do not have to discard of our dominant strategies in achieving sustainability: they constitute a perfect start. We *do* have to augment them though, and for this we will have to increase our investments in *societal innovation*. If successful, a strategy based upon intensified societal innovation will realise an intrinsic sustainable future, and thus solve the dilemma rigidly.

In order to put the above in a strategical perspective, three *sustainability strategies* can be identified[11]:

1. *Laissez faire, laissez aller* (non-interference: passive)
2. *Problem-limiting* sustainable development (responding to and reducing excess: reactive)
3. *Intrinsically* sustainable development (avoiding excess by prevention: proactive).

Until the 1950s and 1960s the relationship between the environment and the economy was very simple. The economy was largely linear: it extracted virgin materials from the environment and simply disposed of waste. When economically attractive or in particularly obvious cases, packaging and materials (such as glass bottles and jars or wooden soapboxes) were reused. A linear economy only becomes problematic when it continues for a long time and its scale grows: resources start to run out and the continuous waste contaminates the environment, to which they start to have a negative impact on life or the wellbeing of organisms at a certain point. In the early days pollution – if present - was only happening on a small scale and was primarily a local issue (large scale pollution was rare). There was no need to intervene on a large scale, so passive attitudes dominated: *laissez faire, laissez aller* was the (non-)strategy of choice. The linear economy remained to be the standard.

However, the scale of environmental problems has gradually increased over the last decades; proven by the emergence of waste and packaging problems such as litter and plastic soup (see Chapter 1 and Chapter B). People have gradually woken up to these developments, and we have now reached a stage at which doing nothing simply is no longer an option. Our current response revolves around *problem-limiting sustainable development*, a strategy that seeks to address developing sustainability problems and tries to contain them as much as possible. Modern-day recycling targets are an excellent example of this: every time the packaging problem turns out to be more serious than anticipated, the goals are tightened a little.

The time of *Laissez faire, laissez aller* is long gone in this day and age: doing nothing is not an option anymore. The second strategy, *problem-limiting sustainable development*, will never lose its value. After all, it is impossible to predict everything, and as soon as unexpected problems rear up, this strategy can be used to fight them. However, problem-limiting strategies usually act as a brake on current economic processes that are still growing. Such a strategy will often receive a lukewarm welcome from the parties involved, and will therefore rarely succeed in actually and rapidly solving the underlying problem. Added to this is the fact that the limitation which should be sufficiently effective to annihilate the problem, does not seem to be so for micro- and nanoplastics.

"As a government, we do not want to act exclusively normative, regulative or facilitating. Furthermore, we also don't want to adopt a laissez-faire attitude. Therefore, a correct combination of diverse measures and the cooperation between government, companies and knowledge institutions will take us far in our experience. We must maintain that approach."

Roald Lapperre,
Director-General for the Environment and International Affairs at the Dutch Ministry of Infrastructure and Water Management

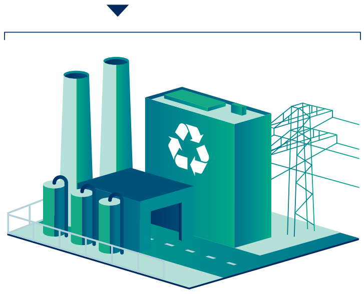
That is why society has a clear need and preference for a third sustainable strategy: *intrinsically sustainable development* (preventing excess situations, proactive). Such a strategy goes beyond "the way we do things now" and beyond solving current problems, focusing instead on anticipating sustainable ways to meet society's future needs and wishes. The proactive, forward-looking combination of developing opportunities and preventing problems, is what makes this third type of societal development *intrinsically sustainable*. As such, intrinsically sustainable development does not put the brakes on today's economy, but proceeds full steam ahead towards new opportunities. Intrinsically sustainable development gives ample room for ground-breaking innovations that can usher in an intrinsically sustainable economy.

On the long run an intrinsically sustainable course of action is far superior to doing nothing *(laissez faire)* or taking a problem-limiting approach in sustainable development. It requires, however, an increased effort in societal innovation on the basis of careful cooperation between societal actors. Our current problem-limiting approaches can be used as a stepping stone, as explained further on in this chapter.

2.3 Climbing the ladder

In this paragraph we will present a ladder for dealing with waste in general, and packaging waste in specific. The original ladder for waste management was introduced in the Dutch governance by the politician Ad Lansink during the late 1970's. The rungs of his original ladder were (from low to high): Landfill, Burning (to recover energy), Sorting and Recycling, Reuse and Prevention. The idea was to climb the ladder as high as possible. Since then the original ladder has changed and developed considerably, for example by taking up circular principles.[12] In this paragraph we will superposition the three sustainability strategies of the above paragraph on an expanded ladder, using the original sources as starting point.

Not so long ago, resource recovery from waste was a rare occurrence: it was done in obvious situations, but not done out of necessity. Waste was disposed of by default, which, in a linear economy, usually happens in one of three ways: waste is redistributed in order to minimise its negative effects by means of dilution (*Redistribution*, e.g. flue gases leaving chimneys, particulate matter, litter, dumping in oceans); waste is collected and concentrated (*Reconcentrate*, e.g. landfills and nuclear waste depositories); or waste is incinerated for size reduction and energy recovery (*Recover*).



This trio of predominantly linear principles can be loosely ranked as a ladder, in which the goal is to climb as high as possible, only descending to a lower rung if necessary *(see Figure 8)*. Reconcentrate is slightly better than Redistribute because it allows for *containing, and mining or remediation* at a later stage. Recover, in turn, typically is better than Reconcentrate, because recovered waste can still be put to good use. The formulation is cautious, as in the end it is the nature of the waste in combination with a processing principle that determines whether the approach is appropriate or not. After all, dogmatism should be avoided. There may be nothing wrong with, for instance, a compost heap made up of biodegradable waste (Reconcentrate) or an intrinsically clean incineration process with energy recovery (Recover).

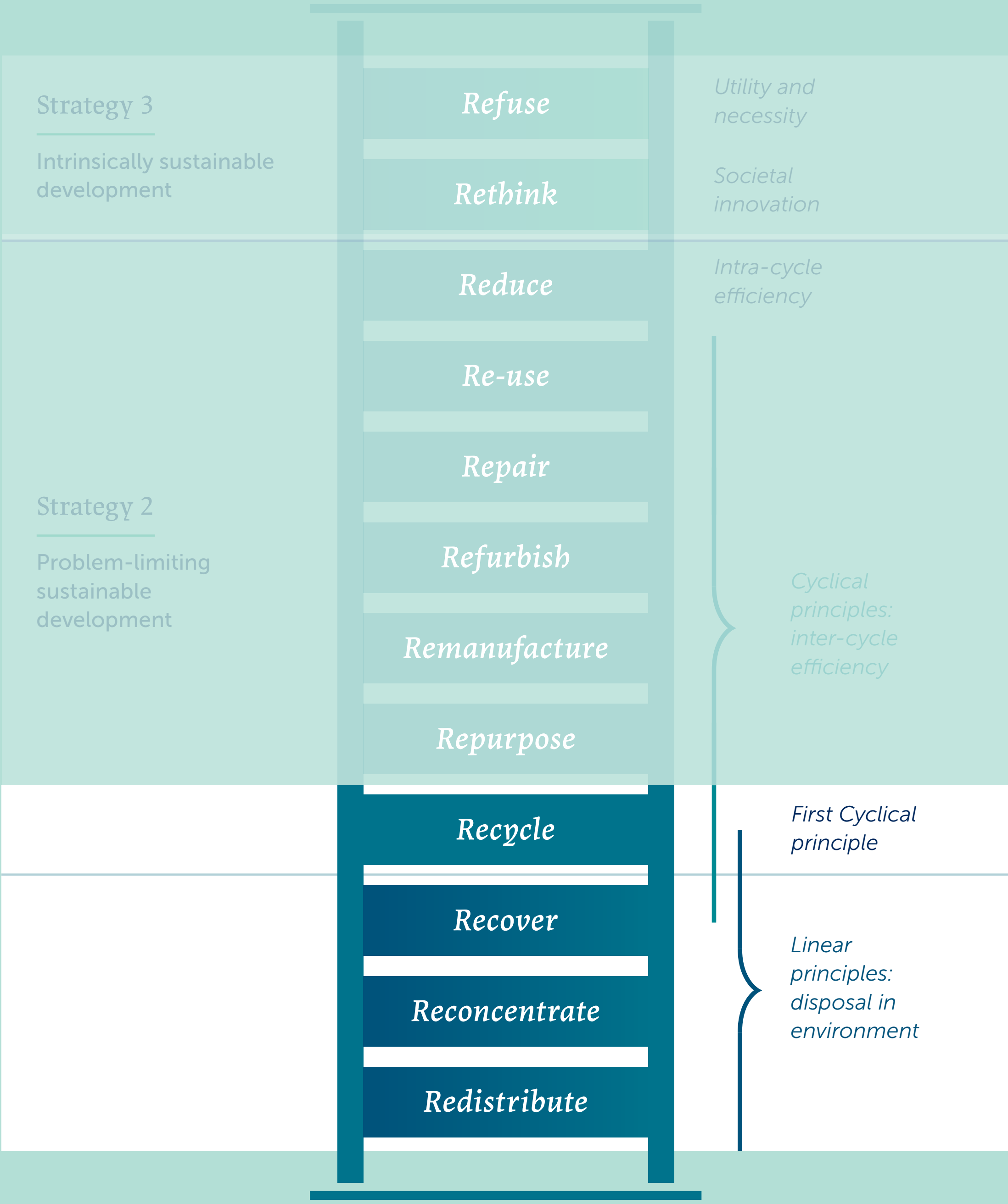


FIGURE 8 - SOME OF THE KNOWN WASTE PROCESSING PRINCIPLES AND THEIR ENVIRONMENTAL HIERARCHY.

Over time, however, packaging flows grew and linearity, as an organisational principle, no longer sufficed. For this reason, recycling has become popular for packaging *(see Box 2, Box 3 and Box 4)*. Simply put: if you introduce the lion's share of your packaging waste to the loop, this share cannot enter the biosphere and will not have to be produced all over again. Recycling can be far-reaching, up to and including chemical recycling *(see Box 4)*, adding another rung at the top of the ladder *(see Figure 8)*.

Recycling collects (packaging) waste at the end of a chain and brings it back into circulation. But there are more ways to introduce circularity in the chain, often at an earlier stage. Besides, recycling is not even the most attractive cyclical processing option out there from an environmental perspective. To grow towards a full-scale *circular economy*, we have a body of various cyclical principles at our disposition.

A circular (or closed-loop) economy is a social-economic system that respects the finite supply of raw (virgin) materials. In this system, waste is not discarded, but reused completely[13] (a more correct way of putting this would be *"as far as practically or thermodynamically feasible"*, see Box 5). The extraction of raw materials and disposal of waste would ideally cease altogether, under steady-state conditions. The aim is to reach this situation through a broad set of cyclical principles, better known as the R-ladder, ranked from bottom to top: Recycle, Repurpose, Remanufacture, Refurbish, Repair, Re-use *(see Figure 9)*. The attempt is to maintain an integral value level as high as possible for a time as long as possible. From this vantage point, recycling is the first rung on the ladder of cyclical principles, on the lowest value level.

Recycling and the circularisation of our current processes of production and consumption are flawless examples of the problem-limiting sustainable development strategy (strategy 2). In *Box 2, 3 and 4* examples are given of new innovation techniques to improve recycling.

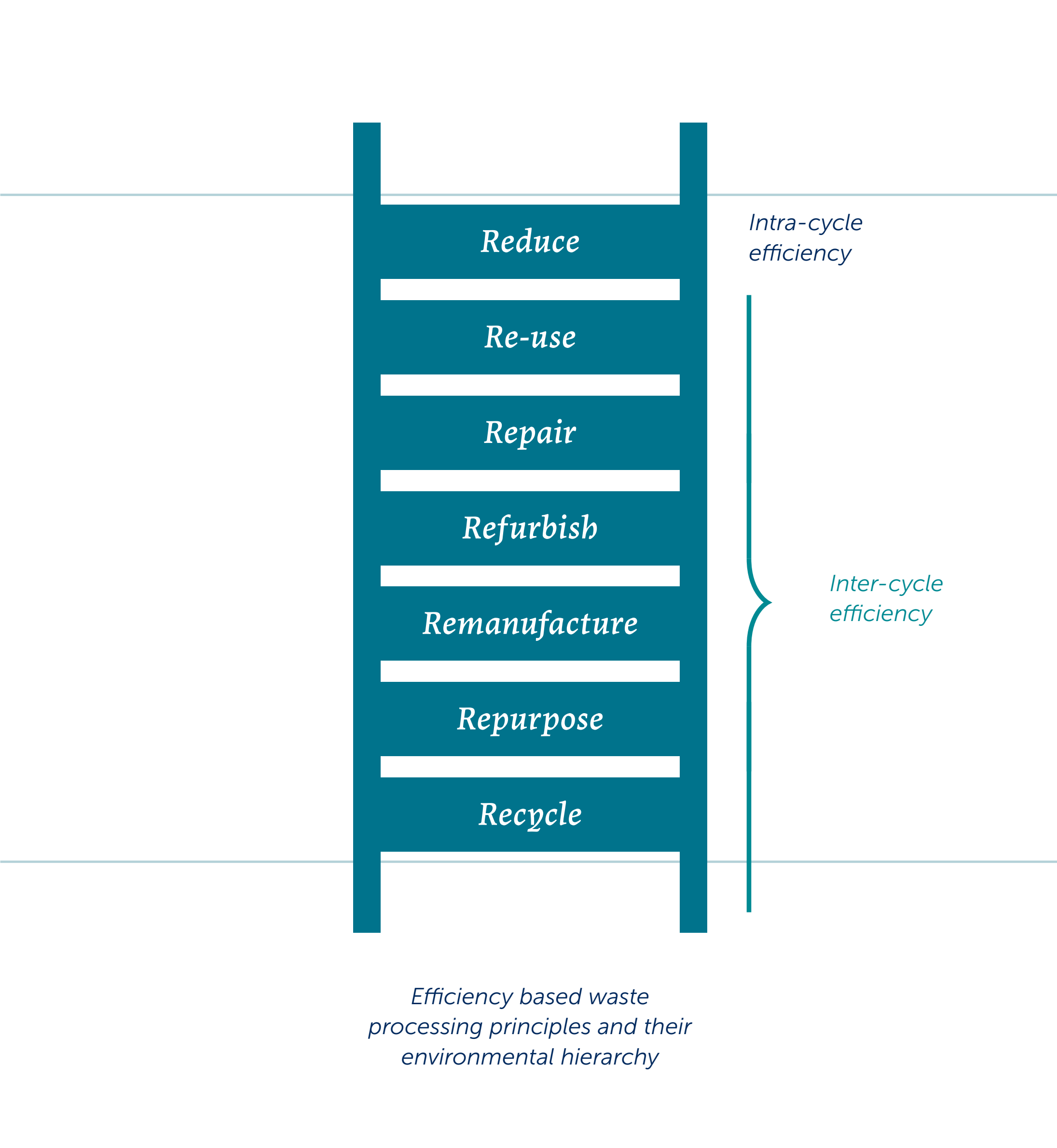
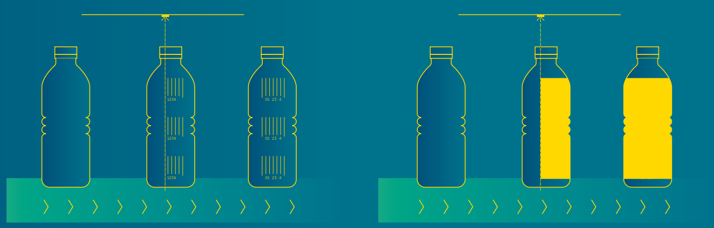


FIGURE 9 - EFFICIENCY-BASED WASTE PROCESSING PRINCIPLES AND THEIR ENVIRONMENTAL HIERARCHY.

Box 2: Innovation of watermarks and tracers
Status: pilot scale

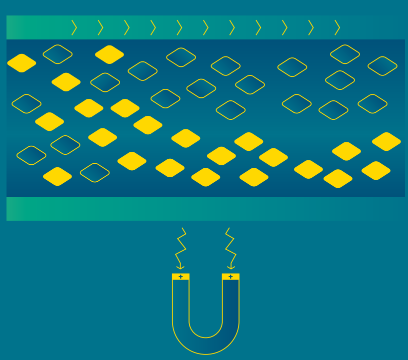
Digital watermarks are images or patterns that can be invisibly integrated into the artwork of a unit of packaging, whereas 3D watermarks are tiny, textured patterns hidden in the packaging. When using the right software and scanners, both watermarks can be recognised during the sorting process.

Chemical tracers are molecules that are added to a plastic mixture or a packaging element, such as a label or cap. These molecules have spectroscopic properties, such as lighting up when exposed to UV light), that are invisible to the naked eye but make it possible to identify the material during sorting.



Box 3: Innovation of new sorting techniques
Status: pilot plant

The Dutch company Umincorp has developed a separation technique called *Magnetic Density Separation* (MDS). It starts with shredding the packaging, after which hard plastics are separated from films. The flakes are then separated by density in a bath of ferromagnetic liquid. Holding a magnet under this liquid creates a density field within the liquid, which causes different polymers to be suspended at different heights, so that they can be separated in a single process.



Box 4: Innovation of chemical recycling
Status: pilot plants

Chemical recycling is the process of returning plastics to their original building blocks (polymers, monomers or other chemicals) by means of a chemical process, so that they can be reused to make plastics or other products. In fact, it is an umbrella term for multiple processing techniques. Magnetic depolymerisation and solvolysis, for instance, have a similar environmental impact to mechanical recycling, but require quite specific input. Gasification and pyrolysis, on the other hand, accept more input but have fewer environmental benefits.[14]

As a result of the diverse loops, circularity introduces a high level of efficiency with respect to the material flows in our production-consumption processes, including packaging materials. The combined circular principles cover inter-cycle efficiency, which results in laying less distress on our natural resources and our biosphere *(see Box 5)*. The same applies within a cycle: we may Reduce materials, by dematerialisation or prevention. All the material you do not introduce into your processes of production and consumption, can never require energy and attention or generate waste and therefore never cause any problems either. We will have to make Reduce a major priority in coming years, which is, fortunately, already in hand. Reduce tops the ladder as an extra-efficient rung *(see Figure 9)*.

Reduce is about reducing the amount of waste produced within a single cycle (intra-cycle efficiency), while the principles of circularity do so over the course of multiple cycles (inter-cycle efficiency). These core, eco-efficient principles should guide the way we deal with packaging and waste streams, now and in the distant future *(see Figure 9)*.

Recycling and increasing circularity are logical steps in the transition from a linear economy to an efficient, circular economy, but such an economy is not the final destination. 100% Recycling or 100% efficiency is both a practical and a thermodynamic impossibility (*see Box 5* for an explanation). Companies are working towards a 100% recyclability and many claims of this type are communicated on packaging. One might expect that this claim truly results in a 100% recycling yield, but that is (of course) not really the case. Easily recyclable packaging is packaging that is compatible with an operational collection system, is suitable for sorting and recycling, and has an application in a new packaging or product. If collecting, sorting and recycling each have a yield of 80%, which is rather high, the overall recycling yield is 0.8 x 0.8 x 0.8 (or $0,8^3$) = 0.51 %. *(See also Figure 10)*. This has nothing to do with the 100% recyclability claims which are often communicated on packaging.

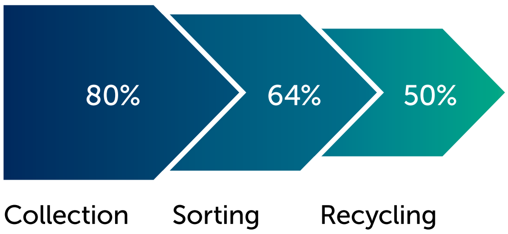


FIGURE 10: AN EXAMPLE OF HOW OVERALL YIELD IS DEPENDING ON YIELDS PER VALUE CHAIN STEP (NUMBERS ARE HYPOTHETICAL).

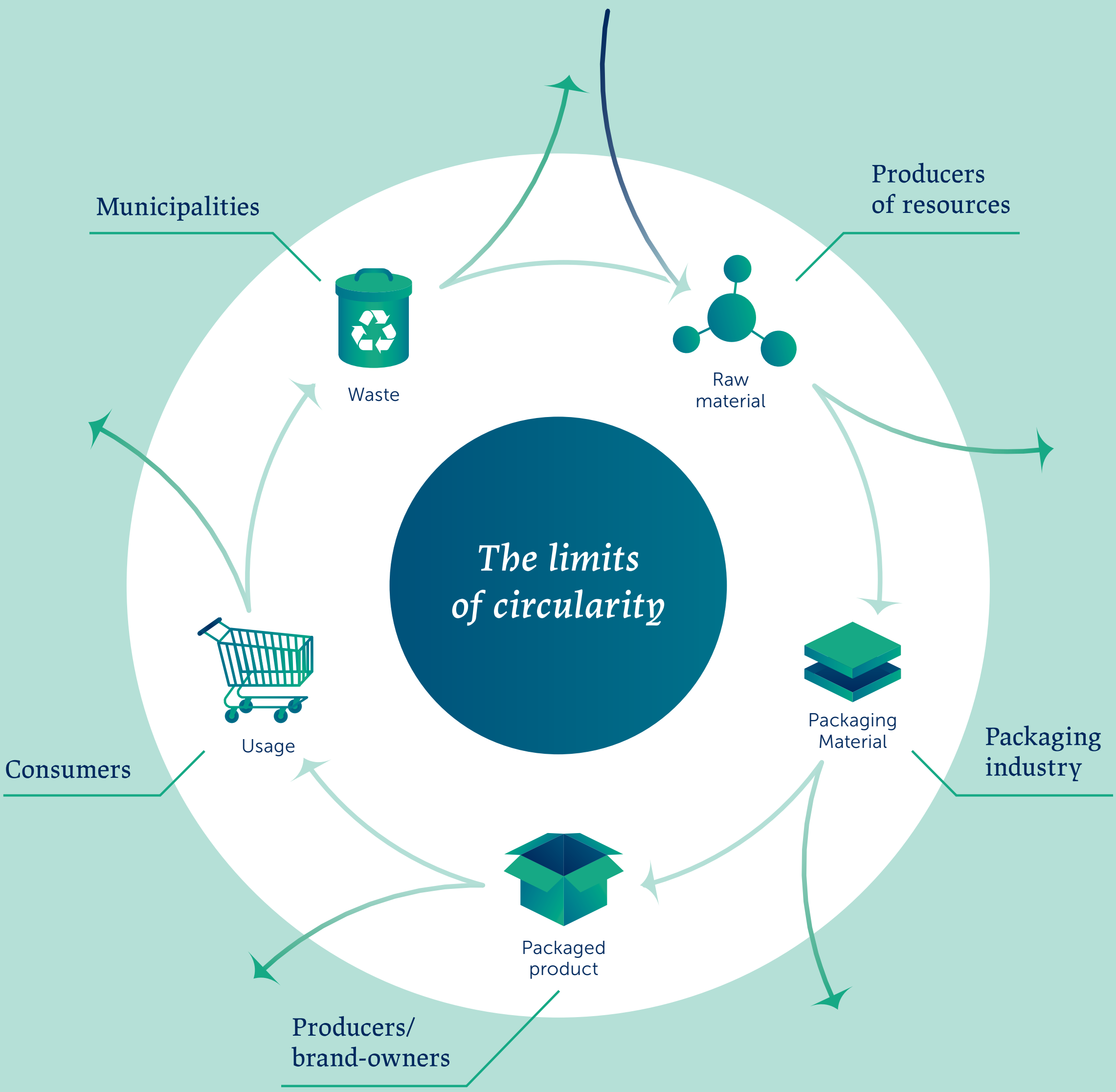
Our production, consumption and packaging processes, whether they be linear or circular, will always exhibit spills and losses, a process known as (thermodynamic) leakage. The very moment that this leakage consists of persistent, contaminant materials (and it does for a considerable part at this moment, see Chapters B and D), it will lead to the accumulation of contamination in our biosphere. Even if, with economic conditions staying the same, we were to tolerate losses of 5% per annum, which would be ambitious given today's recycling rates (even in forerunning countries) we would still pump a year's worth of production into the environment every two decades. The fact that the global economy will strongly grow in the long term, makes it even more essential that we stop structurally leaking contaminating waste into the environment.

"Within the coming five years, the maximally achievable recycling rate for plastic packages in the Netherlands is 72% and this so-called circular economy will still rely largely on fossil oil feedstock, non-packaging after markets and substantial investments."

Dr. Ulphard Thoden van Velzen,
Senior Researcher Packaging Technology and Recycling
at Wageningen Food and Biobased Research,
The Netherlands

Box 5: The limits of circularity

If we were to develop fully closed-loop, 100% efficient systems of production and consumption, to the point that they constitute an entirely circular economy, the packaging problem would be solved with the second strategy: problem-limiting sustainability. After all, there would be zero waste and pollution. Fully closed loops and complete efficiency do indeed sound like a very promising duo. Unfortunately, the old adage applies: if it *sounds* too good to be true, it probably *is* too good to be true. Fully closed loops and complete efficiency are an impossibility, for various serious theoretical and practical reasons.[15] The laws of physics determine that fully closed loops and perfect efficiency are fundamentally impossible. Systems can never be completely isolated from each other for thermodynamic reasons.



Why completely closing the loop is not possible, and therefore will not suffice as a strategy, can also be understood in terms of more practical reasons. First of all, the constant increase of resources extracted and discarded will be a difficult trend to buck. The global population is still growing and more and more people in emerging economies are enjoying the benefits of modern chains of production and consumption. Without an adequate response to this the use of packaging and the attendant packaging problems are only set to increase.

Furthermore, the loops we are looking to close are complex: the many routes and paths that packaging takes through our global processes of production and consumption, literally passing by billions of people many times a day, combine into staggering networks. It is practically impossible to turn all systems and subsystems of production and consumption into closed loops. This is exemplified by our experiences with mono-materials such as glass. Despite the fact that we have decades of experience with recycling glass in the Netherlands, and the recycling rates were growing fast at the beginning, it seems that we have reached a limit. Reaching a recycling rate of more than say 90% proves to be a considerable challenge, and with a certain loss to use the collected glass for new bottles due to color issues and impurities this shows that it is hard to reach high levels of recycling in a relative simple material cycle.

But doesn't common sense dictate that increasing our efforts will get us closer to fully closed loops than we are now? For the near future this surely works, and we most certainly must continue this route. Investing in circularity and efficiency will diminish the use of virgin materials and pollution of our biosphere considerably, in comparison with not investing at all (see the efficiency rungs of the ladder above). But it is not a rigid solution on the long run due to thermodynamic leakage. We will hit an asymptote: at a certain moment in the not-so-far future, investing more and more (effort, research, attention, money, etcetera) will have less and less effect.

Striving for maximum circularity and efficiency are of the utmost importance. However, this will not be sufficient to solve the packaging dilemma rigidly in the long run. The progress shown by validated real world recycling rates of forerunning countries will inform us about the pragmatic limits of circular approaches.

In summary, this is the framework for future production and consumption and packaging:

> *Whatever resources we extract from our biosphere must never be missed (scarcity, possibly leading towards exhaustion), and whatever waste disappears back into our biosphere must never contaminate.*

Whatever resources we extract from our biosphere must never be missed (scarcity, possibly leading towards exhaustion), and whatever waste disappears back into our biosphere must never contaminate.

In this respect, the *planetary boundaries* to be discussed in Chapter B speak for themselves. Any material returned to the environment must either be natural or degrade quickly to harmless substances before it can spread. "Natural" and "harmless" are those substances that were abundant during our human evolution or are rigidly proven to be harmless. This is what makes them biosphere-compatible.

If we are to ensure that our economies do not stray from this framework, we will have to do more than use existing technologies and materials in a circular, efficient manner. We will have to start making the very nature of these technologies and materials the subject of innovation. The falling leaves during autumn provide food for thought: every year, they constitute a large-scale "waste stream" that does not cause any problems whatsoever. This is because there are no exhausting or contaminating processes involved: notwithstanding the enormous scale, reflected in the yearly fluctuations of atmospheric carbon dioxide concentrations (see the Keeling curve[16]), the growing and falling of leaves fit seamlessly into the biosphere. In *Box 6*, the innovation of bio-based packaging, a possible precursor of such an approach, is explained.

Box 6: Innovation of bio-based packaging
Status: first large-scale applications

Bio-based plastics are mainly made from natural raw materials such as sugar cane and corn starch. This class contains entirely new plastics such as PLA (Polylactic Acid), mainly known from the green plastic packaging used by organic meat producers, as well as bio-based alternatives for existing plastics. The latter group, also known as drop-in bioplastics, includes bioPE, for instance, as used in Ecover bottles and bioPET, known from Coca-Cola plant bottles, which have the same chemical properties as their fossil counterparts. These bio-based materials can be more sustainable in terms of their raw materials, provided they are grown in a responsible manner. When discarded, however, they have the same potentially harmful properties as fossil plastics. Combustion releases the same amount of carbon dioxide, but because the plants that form the basis of these plastics also absorbed carbon dioxide from the atmosphere at an earlier stage, the carbon loop can still be considered closed. Besides, these drop-in alternatives can be recycled in the same stream as fossil plastics.

In light of this framework, there are vacancies for two more environmental processing principles on top of the ladder, corresponding to higher levels of ambition: *Rethink* and *Refuse*.

Refuse is at the very top of the ladder: it states that any process, product or packaging material that does not meet the demands of the framework above, that is functionally questionable and environmentally undesirable and unsustainable, must be identified and halted. It is a principle of hard *utility and necessity*, a societal cost-benefit assessment that takes into account environment, health and economy. Systems of production, consumption and packaging that do not fit society's key criteria (avoiding exhaustion and contamination) must be modified and, ultimately, put to a halt.

Rethink is, in fact, the creative and development-minded counterpart of *Refuse*. It calls for profound innovation to catalyse the transition to systems of production, consumptionand packaging that serve both environment and health *and* the economy, *principally* bridging and in the end eliminating the gap between them. This crucial step places significant demands on our ability to innovate *(see Figure 11)*.

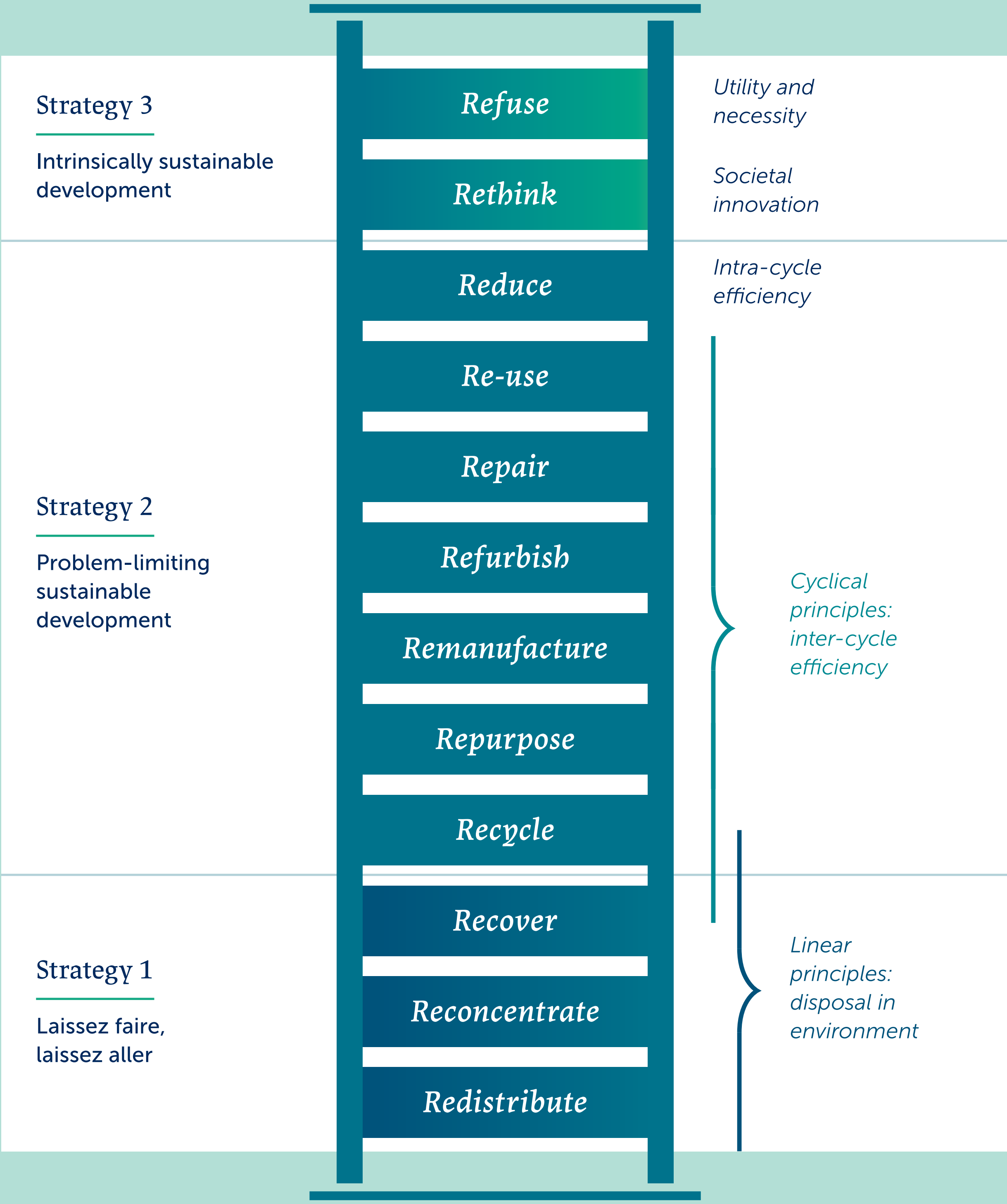


FIGURE 11 - WASTE PROCESSING PRINCIPLES AND THEIR ENVIRONMENTAL HIERARCHY. THE SUSTAINABILITY STRATEGIES ARE POSITIONED NEXT TO THE CORRESPONDING PART OF THE LADDER.

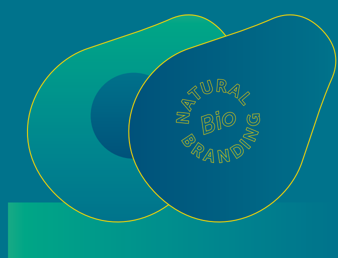
We must stop the massive extraction of virgin materials and discarding waste after processing and use (linear principles). We should always be as efficiently as possible (efficiency principles). But more than anything else, we should introduce a type of innovations that change the nature of our societal multi-actor practices, our technologies and our materials. The goal is to bring our complete production-consumption processes once again in agreement with our planetary boundaries, and preferably even in symbiosis with them. If necessary, we need to redesign systems substantially or even start from scratch, in terms of new partnerships between parties involved and them to start new behaviours. Rethink requires ground-breaking innovation that not only gradually improves what already existed, but also rapidly creates what we do not have yet. Both economic and ecological effectiveness come first; efficiency is secondary. Together with Refuse, Rethink implements a societal transition towards an intrinsically sustainable society (strategy 3 from the previous section), thus completing the ladder *(see Figure 11)*.

When employing strategy 3: Intrinsically sustainable development, high up in the ladder, the other steps remain just as important. If you remove them, the ladder will inevitably collapse. This is partly due to the fact that at start, larger innovations are primarily concerned with effectiveness: they raise the bar in terms of value. Only when the innovation proves successful, attention will be paid to efficiency (the lower rungs). A second reason, however, is that it is impossible to predict in advance whether yesterday's and today's linear principles, put to use in another material context, might not turn out to be incredibly sustainable after all. For example, the methods used on compost heaps today (Reconcentrate) may also be suitable for future waste streams of another composition.

Box 7: Innovation of rethinking labelling
Status: market ready

To the great frustration of many an aware consumer, supermarkets selling organic fruits and vegetables still use plastic packaging.

Natural Branding is a natural, eco-friendly way to mark a piece of fruit or vegetable by applying letters or an image on the rind or skin. Natural Branding saves tonnes of plastic and other packaging materials every year. Products such as avocado, courgette, ginger, coconut, cucumber, mango, pumpkin and sweet potato are already sold with Natural Branding.

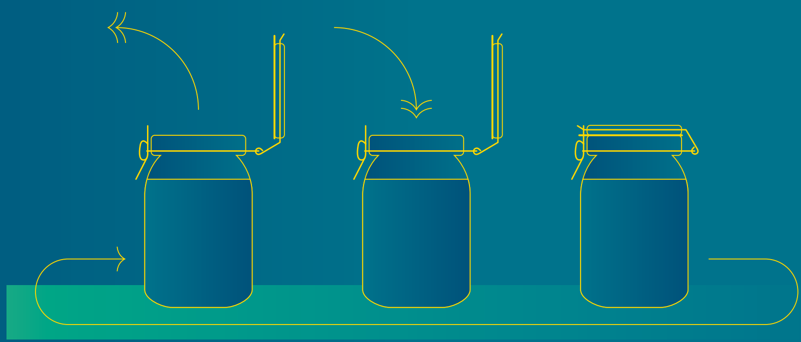


We must regain respect for the finite nature of our biosphere's resources and better monitor and manage their quantity and quality, even at the enormous levels of the scale characteristic of the 21st century. That is the challenge we will face for the future. We will have to rely on all the steps of the ladder, initially climbing the lower end before quickly proceeding to the top. After all, as a society we are on the way to intrinsic sustainability, which will require us to adopt strategy 3: intrinsically sustainable development. In *Box 7 and 8* examples are given of new innovation techniques of climbing the ladder.

Box 8: Innovation of reuse
Status: pilot scale

Reused packaging is on the rise, or rather on the rise again. Before the advent of today's cheap plastic packaging, reuse was common, especially for glass packaging. Driven by the public's resistance to single-use plastic packaging, systems based on reuse are making somewhat of a comeback, albeit on a much smaller scale than before. Online shopping is steadily becoming easier and more common, which, in turn, makes it easier to combine delivery services with reusable packaging.

Products are delivered in reusable packaging, which is to be picked up at the next delivery, after which it will be filled with a new product and returned. This process, though, comes with major logistical challenges.



"There are a number of reusable, refillable packaging concepts that have been trialled but there has been no strategy driving it. No evidence base to build it upon. They are marketed with a lot of positive PR, but then they don't turn out as successful as expected or hoped because the foundation work has not been carried out beforehand. This also explains why there is not so much feedback or data about refill programs. The main reason is that we haven't understood what user-centric design is – we don't think too much about the design of the packaging."

Tracy Sutton,
Founder and Lead Consultant at Root,
The United Kingdom

2.4 Societal development and sustainability strategies

The ladder presents a loose, yet orderly hierarchy of methods for dealing with waste, including packaging waste. *Grosso modo*, and especially in terms of sustainability strategies, the adage is: the higher the better. Societal development, however, is considerably less straightforward. In order to achieve an intrinsically sustainable economy, society's ultimate goal, we cannot simply turn the ladder upside down. History matters! (See also Chapter 1). We will have to deal with the legacy of centuries of technological and economic development, which can be beneficial, but may also put up a fight in the face of sustainable change. In practice, we will often find ourselves on several steps of the ladder at the same time: it's not wise to take a step upwards and immediately disregard the steps on the lower part of the ladder. Nevertheless, a clear understanding of the principles underlying the ladder and the three sustainability strategies will show the way to a bright future. This does, however, require some awareness of where we came from, as a society, and where we are headed for. In this paragraph we will therefore situate the three sustainability strategies in time, making use of "The path of humanity": a description of the path of societal development from our past into the future.[17]

Long before modern times, we lived as nomadic hunter-gatherers in small-scale, low-tech, interdependent groups. Hunter-gatherers living in the same group had clear insight into what everyone was doing, which certainly does not apply to today's enormous production-consumption chains. People were self-sufficient, as is testified by the name of this phase: Autarky. The Autarkic Society was *fundamentally circular, intrinsically sustainable and highly reciprocal*, at least in the early days when communities were still few and small (although they were not aware - it would take the development of our Modern Society to "invent" these concepts). The first strategy, *Laissez faire, laissez aller*, was well in place.

The Modern Age was ushered in by the scientific revolution of the 17th century, which prompted a long series of scientific and industrial breakthroughs from which we all reap the rewards. The growing imbalance between the economy and the environment, however, is a typical symptom of our Modern times. The reason is that we initially continued along exactly the same path as during Autarky, linearly taking whatever we needed from our environment and discarding what we no longer needed, such as packaging waste. There are, however, a number of key differences between Modern Society and the societal practice of our Autarkic predecessors, which make further continuation impossible. These differences are:

1. **Scale**. Modern production and consumption have reached levels of scale that far outstrip those of our Autarkic days. The same applies, *mutatis mutandis*, to the extraction of raw materials and the disposal of waste.

2. **Dissemination**. In the Autarky, extraction and disposal had a local scope. In the Modern Age, however, we can source our materials from all over the world, disposing waste in our biosphere on a global scale. A lot of plastic, for instance, is made from fossil fuels, which are traded globally, and litter and by-products of combustion such as carbon dioxide and particulates have little regard for borders.

3. **Technology**. Processes are no longer natural but technological by nature, and the materials used are often artificial. As a result, the properties of waste have changed radically. Just compare the decomposition rate of leaves to that of tin cans or plastics *(see Figure 12)*.

4. **Interdependence**. Whereas the members of a group of hunter-gatherers knew each other well and depended directly on each other, the enormous and growing numbers of parties constituting our complex, late-modern societies are becoming increasingly alienated from each other.

These differences turned the Autarkic economy, characterised by *biosphere-compatible circularity, intrinsic sustainability and interdependence*, into the Modern economy, which started *linear*, and soon grew *unsustainable and even externalising (passing on costs to specific groups and future generations)*. As a consequence, problem-limiting sustainability strategies (Strategy 2) were developed to address the growing Modern problems.

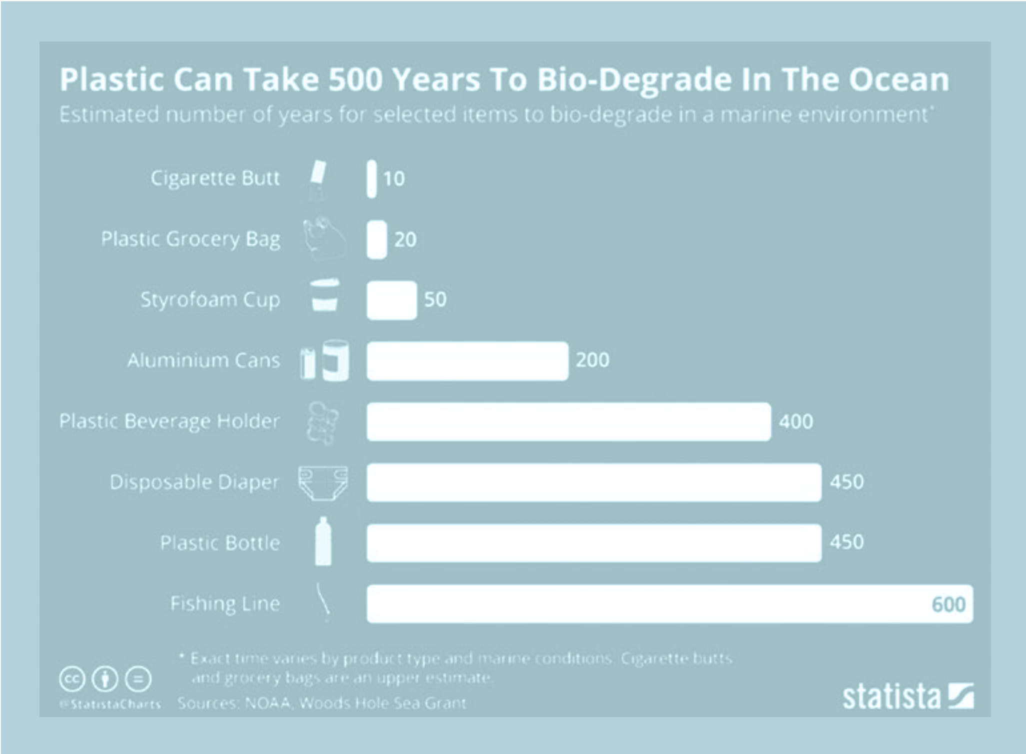


FIGURE 12 - BREAKDOWN TIMES OF PLASTIC PRODUCTS.[18]

We are now living in the late Modern Age. Problem-limiting strategies are falling short. Once again, we will have to reinvent our production-consumption processes, our societal processes as a whole. There is a lot we can learn from our Autarkic predecessors: we can use the Autarkic guiding principles (*biosphere-compatible circularity*, intrinsic *sustainability*, *reciprocity*) to take the next step towards a Plurimodern Society: a society that reconciles scale with many different requirements and needs. The difference is that we will have to apply these guiding principles on previously unimaginable levels of scale. The very first trailblazers are now entering this new phase: the Plurimodern Age (a portmanteau of pluriformity and modernity).

Figure 13 shows how we deal with packaging, leading from Autarky (Phase A) to the early, mature and late Modern Age (Phases B-D), before terminating in our future: the Plurimodern Age (Phase E). As time flies, the appropriate sustainability strategy shifts from Laissez faire, laissez aller via Problem-limiting towards Intrinsically sustainable.

The first two phases (A and B) are mainly behind us. Phase C, the short term (see *Present* at the time axis), characterised by recycling and efficiency, is in full swing. Phase D, the medium term, characterised by far-reaching circularity and efficiency, has already been set in motion and we are starting to see initial results. *Box 9* gives an example of a circular product. Phase E, featuring intrinsically sustainable societal systems, is still in its very early days, with tentative initiatives cropping up here and there, and for this very reason this phase is the most unclear.

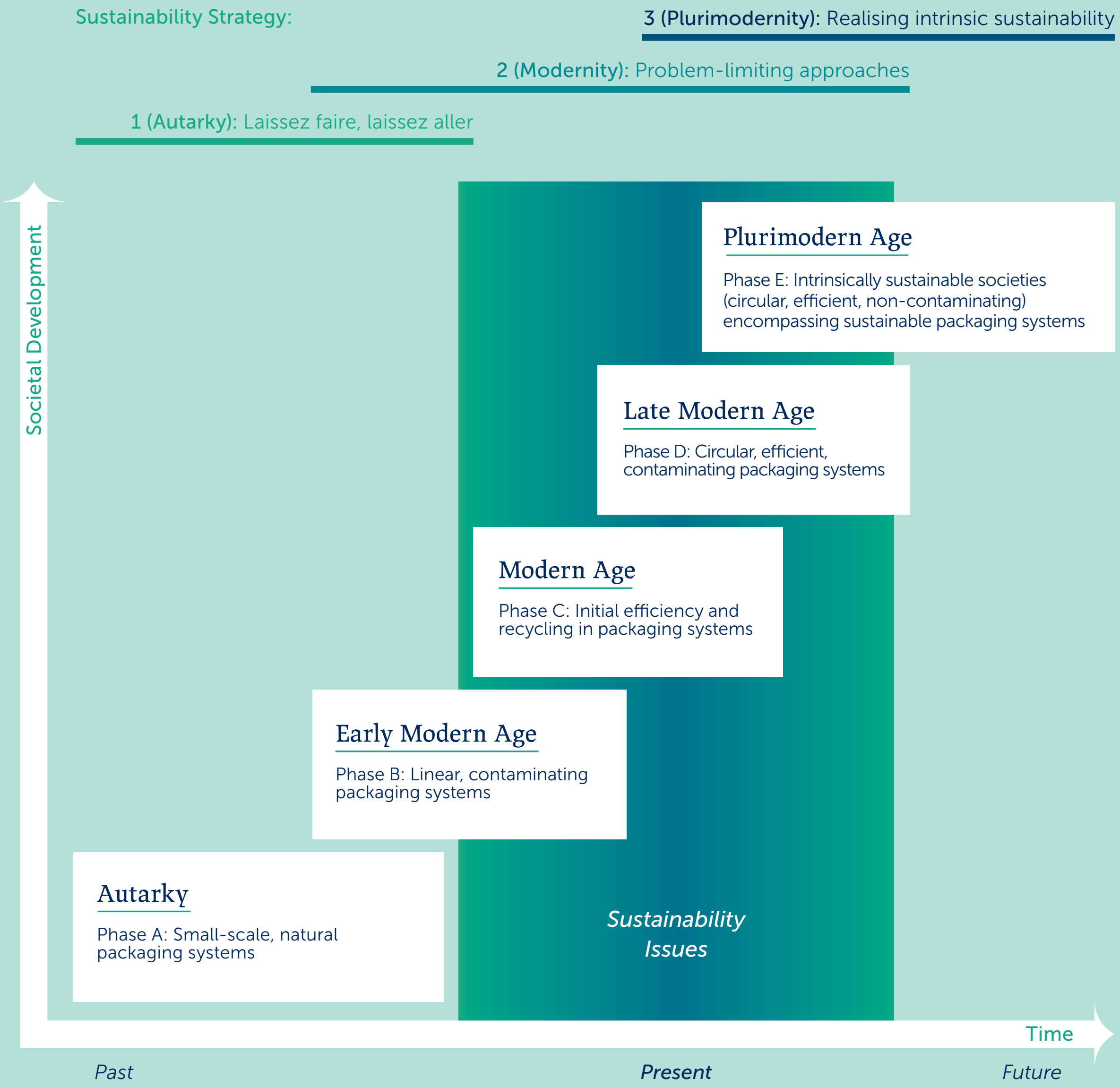


FIGURE 13 - SOCIETAL STAGES IN DEALING WITH PACKAGING.[19]

These innovations go beyond sustainable packaging: it is about intrinsically sustainable concepts, products, services, and consumption which fulfill the needs and desires of society. Packaging is integrated and part of the sustainability. Phase E will become clearer as we proceed.

Box 9: Mixed plastics for the production of pallets

After PMD (plastics, metals and beverage cartons) waste has been sorted in the Netherlands, the seperated components remain, mixed plastic included. AVK Plastics, in cooperation with Attero and Prodin, investigated to what extent the polyolefin fraction (PO) from mixed plastics can be processed into high-quality and recyclable logistics application of pallets. Pallets made from recycled plastics are claimed to be more sustainable than pallets made from wood, because they last longer.[20]

2.5 Our common future requires societal innovation

In order to develop efficient circular packaging (Phase D) and intrinsically sustainable packaging (Phase E), we must go beyond casuistry and improving packaging. When making serious progress in Phase D and entering Phase E, the required innovation processes challenge (in case of Phase D) and even overstrain (in case of Phase E) the work and influence areas of companies, for example producers and packaging specialists. The analysis of Chapter 1 learned that rigidly solving the packaging dilemma is a societal challenge and requires societal cooperation. After all, "the packaging system" is closely intertwined with and depending on the impressive global systems of production and consumption that feed and support society today. These systems encompass many different branches of business life (such as producers, logistics, and retail), governments on several layers and consumers. On top of this, innovation at the scales of Phase D and E requires intensive co-operation and involvement of the knowledge infrastructure (universities and knowledge institutes) and intermediate parties engaged in knowledge brokerage activities. All these parties will have to co-operate and change accordingly.

Guiding our society to circularity and intrinsic sustainability therefore calls for a new attitude towards innovation. We have to expand our arsenal of innovative methods, use them in combination, and consider different levels of scale at the same time. This is what we call *societal innovation.*[21] Below two ways will be presented to understand societal innovation: in terms of combining optimizing and pioneering, and as concentric circles of partnerships.

Societal Innovation: optimising and pioneering innovation methods

To clarify the scope of societal innovation, two sets of innovation methods can be distinguished: optimising methods and exploring (pioneering) methods. This results in six innovation methods, which in combination enable societal innovation.[22]
The three methods of optimising innovation are:

1. (*Technical*) *Process optimisation*: producing the same end products in an improved manner, e.g. better sorting machines for plastics.

2. *Utilisation optimisation*: producing the same end products more efficiently (e.g. optimising utilisation levels by reducing *idle time*, minimising production waste losses, shortening critical paths).

3. *Team optimisation*: producing the same product with improved cooperation (e.g. better cooperation between operators in a recycling company to get more or a higher quality recyclate).

The three methods of exploring/pioneering innovation are:

4 *Product-service innovation*: developing a technically better product and according services e.g. a new way of packaging cheese with improved product quality and a much better recyclability of the packaging, or an intrinsically sustainable packaging.

5 *Multiplication/upscaling (expansion; linear growth)*: expanding production capacity, making more of the same, e.g. doubling a production line at a recycling company.

6 *Coalition building*: meeting the interests of more parties, greater inclusivity, e.g. producers of packaged goods developing new product-packaging combination in coalition with the waste processing industry.

Societal innovation requires that we become skilled in *both* sets of innovation methods, optimising and exploring/pioneering, *and* that we learn to alternate and combine all six of the basic innovation methods intelligently during our journey to intrinsically sustainable packaging. Both innovation methods sets are explained in *Box 10* Intrinsic sustainable development initially calls for far more attention for pioneering innovation than for optimising innovations (the latter typically manifesting more incremental improvements).

Box 10: Optimising versus pioneering methods of innovation

Optimising methods of innovation lead to exactly the same end product (or more general: result) as before, but do so more efficiently. Optimisation takes place strictly "inside the existing box", with *process optimisation* being the best-known example. Process optimisation involves improving the processes underlying an *existing* product and/or service by consuming less energy or producing less waste, for example. Process optimisation focuses on the techniques used. Other examples of optimisation include *team optimisation* (focused on improving cooperation between parties, e.g. deposit return systems (DRS) for B-to-B packaging) and *utilisation* optimisation (focused on resources and materials, e.g. minimising the waste of used materials, dematerialisation). Optimising methods often target efficiency and tend to be gradual, putting them on the lower and middle rungs of the ladder *(see Figure 11)*.

Pioneering methods of innovation look for additional room for improvement "outside the existing box". They revolve around effectiveness and challenge and push boundaries in increasingly extreme ways. The best-known example of pioneering innovation is *product innovation*, aimed at developing new or better products or product-service combinations. Take ready-made meals, for instance, made tastier by using better packaging. The aim of product innovation, then, is to increase the performance of the end product. Other examples of pioneering innovation methods include *coalition-building* (focussing on parties and emphasising new coalitions, e.g. adding more players to include a return system) and upscaling (focussing on resources and materials, e.g. making processes, products or services available in greater quantities for more users).

For an elaboration on the different innovation methods and their combinations, see the original source.[23]

For executing Strategy 3: Intrinsically sustainable development, we will need far-reaching explorative and pioneering innovation: technologies and products will change, parties and coalitions will change, and resources/materials will change. These innovation methods target effectiveness and often go in leaps (rather than in incremental steps): they are required for the highest steps on the ladder *(Figure 11)*.

Typically, the three pioneering explorative value orientations (4-6) are called for in times of change, as they seriously question and change existing boundaries. They are relevant predominantly at the start of and during the first part of life cycles of new societal practices. The three optimising value orientations (1-3) are called for in the latter part and at the end of life cycles, when the value box is clear, and the changes become smaller. At that very moment the practices are most prone to creative destruction (Schumpeter[b]): they are at risk of being replaced by newer, better practices (disruption[24]). In terms of transition, therefore, a substantial role should be given to the explorative (pioneering) value orientations, which search for the societal practices of the future. In the long run, changes from predominantly exploring towards predominantly optimising modes of innovation will show themselves, resulting in the well-known cumulative bell curves (s curves) used to depict the idealised unfolding of transitions.[25,26]

b THE GERMAN ECONOMIST SCHUMPETER EMPHASISED THE NECESSITY OF DESTRUCTING THE OLD ECONOMIC ORDER AS A CONDITION FOR HAVING ROOM FOR THE CREATIVE NEW ECONOMIC ORDER: A TRANSITION THAT MAY CAUSE A LOT OF PAIN AND THEREFORE SHOULD BE UNDERTAKEN WITH SUBSTANTIAL SOCIETAL CARE.

Societal innovation in concentric circles

Innovations in the packaging system begin mostly with thinking about innovating *individual packaging* *(see Figure 14)*. Focusing solely on individual packaging, however, will result in neglecting the enormous improvement potentials of taking into account larger system boundaries. Accordingly, we will soon have to expand our focus to innovating *product-packaging combinations*.

This scale, however, is still too small for innovative trend-bucking: ultimately, we will have to innovate the *functions* of products and packaging (see also Chapter A). Progressive companies have already picked up this gauntlet.

We will need to prepare for the societal innovative steps towards an intrinsically sustainable future. Innovative answers to the question: what are *society's needs and wishes and how can they be fulfilled*? will shed light on the new ways in which the functions and functioning of production-consumption systems will be determined. This question addresses the full societal scale of multi-actor practices in achieving intrinsic sustainability. It will require the use of all six innovation methods in combination and the simultaneous operation on the various levels of scale.

> *"Sustainability loves scale, even though the packaging situation differs per country, we aim for circular packaging for various markets, instead of a solution specific to the Netherlands and another specific solution for Germany."*

Robbert de Vreede,
Executive Vice President Global Food
at Unilever

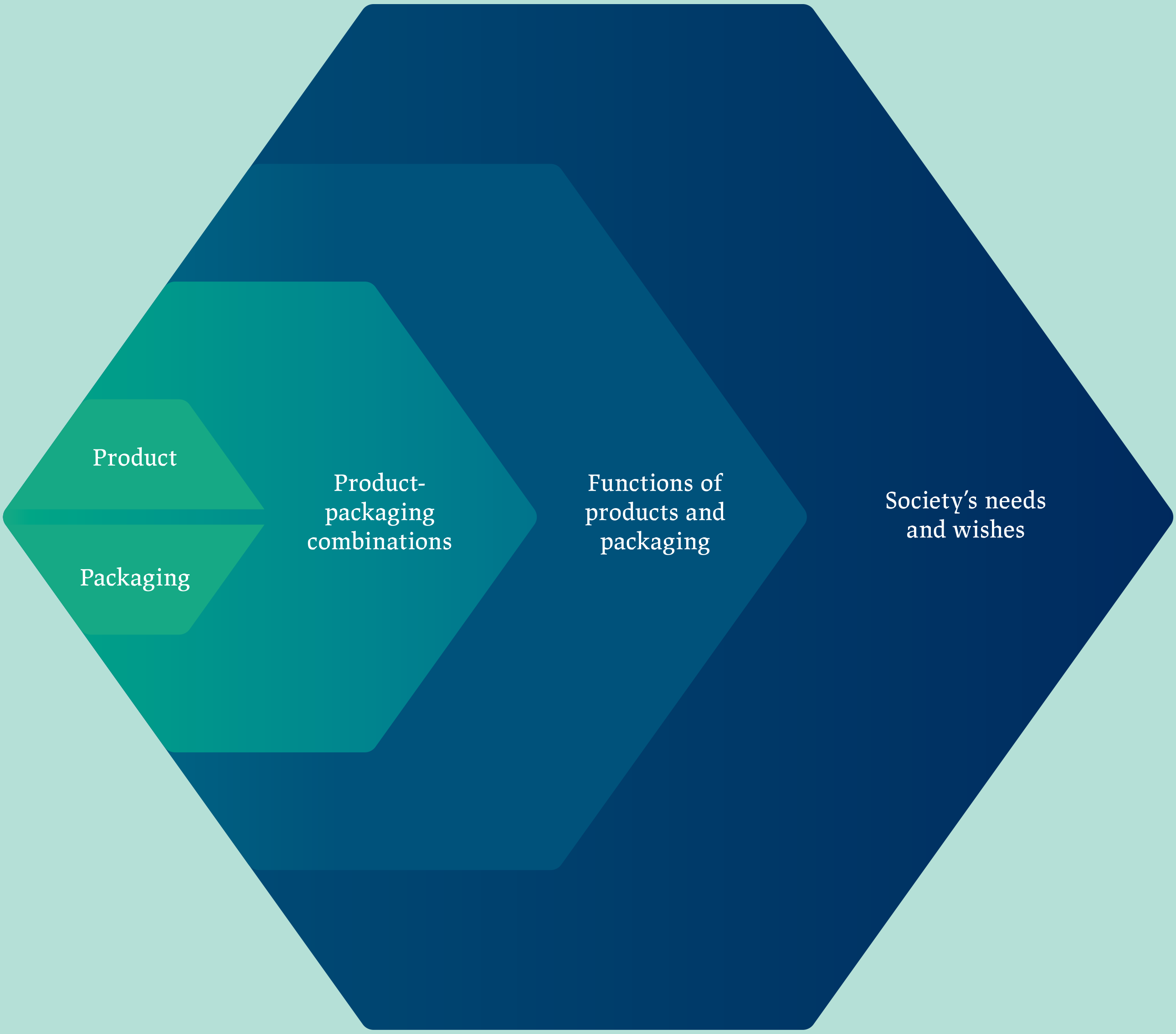
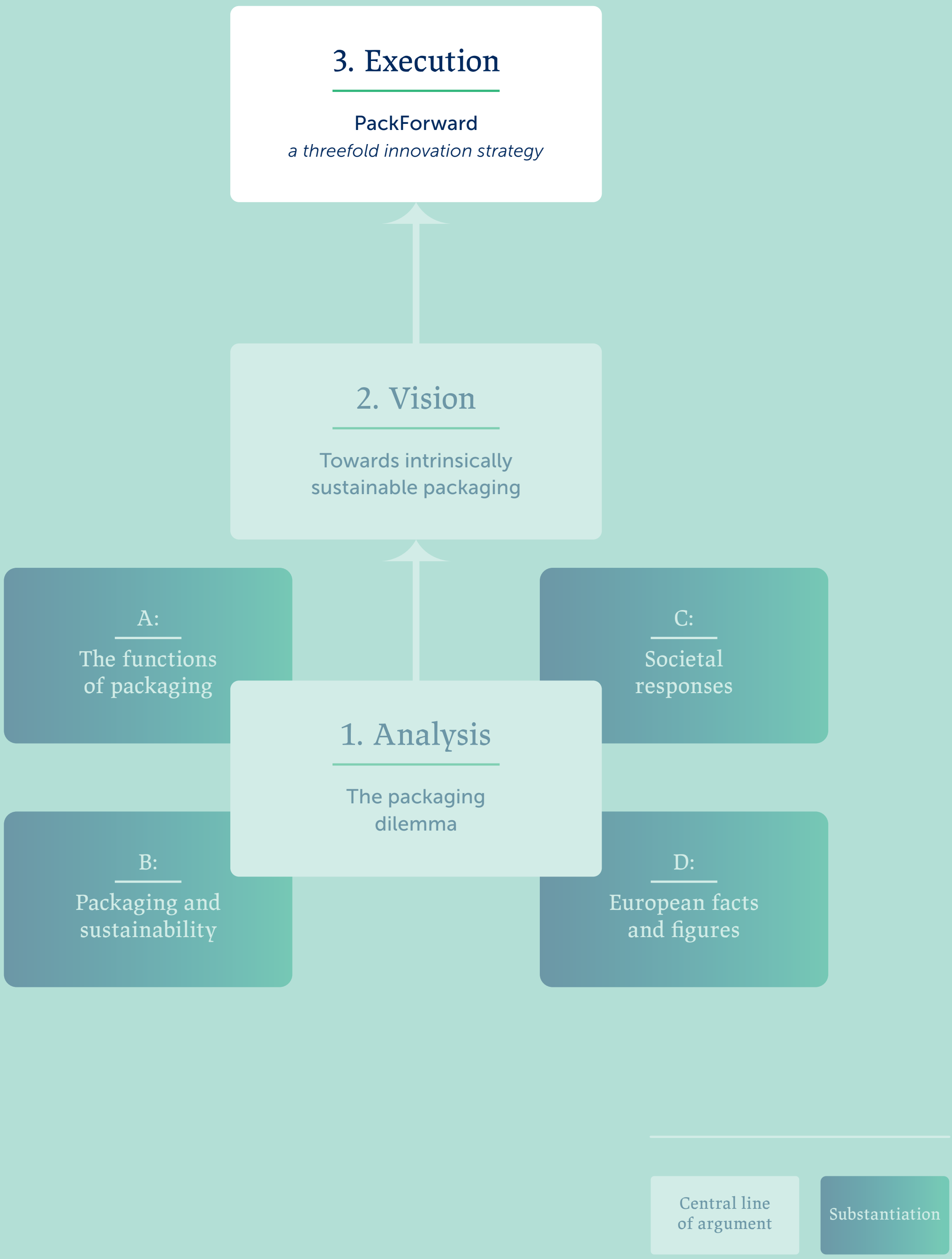


FIGURE 14 - SOCIETAL INNOVATION REQUIRES INNOVATION AT VARIOUS LEVELS OF SCALE AND ABSTRACTION.

Societal innovation requires societal coalitions

Intrinsic sustainable development takes place on various scale levels simultaneously, requiring the integration of different methods of innovation. It goes without saying that such development is not merely the purview of individual production or packaging companies and that its scope goes far beyond packaging. Packaging alone may be innovated by a limited number of companies working together, but as the scale of innovation increases and as we start to use both optimising and more ground-breaking pioneering and exploring methods of innovation, the playing field will quickly expand to consumers, governments and other parties in society. It asks for the contribution of all players in the existing dilemma to change and solve it. Once again, the conclusion must be that completing the travel towards intrinsically sustainable packaging will have to be a societal exertion.


3. Execution
PackForward
a threefold innovation strategy
2. Vision
Towards intrinsically sustainable packaging
A:
The functions of packaging
C:
Societal responses
1. Analysis
The packaging dilemma
B:
Packaging and sustainability
D:
European facts and figures
Central line of argument
Substantiation

Chapter

3

Execution:

PackForward, a threefold innovation strategy

3.1 Introduction

A lot of ground has been covered so far. Chapter 1 presented the *packaging dilemma*, and solving it is exposed as a societal challenge. Companies, governments and citizens-consumers cannot suffice any longer by simply pointing a finger towards each other. Chapter 2 offered a *strategical vision*, progressively leading towards an intrinsically sustainable society. This strategical vision builds on three strategies in dealing with sustainability, takes note of a conceptual ladder of different modes on how to deal with (packaging) waste and describes our human development in terms of five societal phases in time, covering both the way in how the packaging and sustainability dilemma has emerged in our past, as well as the ways of thinking that are of help in dissolving the dilemma in our future. The vision emphasizes that our future dealing with the packaging dilemma must be founded on intensive societal cooperation and innovation.

This is all fine and good, but the risk of societal visions, however urgent they may be, is that they may never leave the drawers, leaving the supertanker no other choice than to continue its - old and non-sustainable - route. The central remaining question, therefore, is how to make swift progress towards truly sustainable packaging. This last chapter attempts to provide the first answers to this question. Answers that are as practical as is possible, but also as ambitious as is needed.

These answers are provided below by means of a *threefold innovation strategy* that builds on the central themes in this report so far. This innovation strategy honours and sets up the space for the many ongoing conceptual and practical efforts in realising a more sustainable packaging at this very moment. It straightforwardly follows from the strategical vision, presented in Chapter 2.

3.2 A threefold innovation strategy

The strategical vision of Chapter 2 consists of five phases in dealing with packaging and sustainability, leading from Autarky to the early, mature and late Modern Era, before terminating in the Plurimodern Era of the future. The first two of these are mainly behind us and we are now in the mature Modern Era, gradually entering the late Modern Age, and cautiously preparing for making the first small steps towards an intrinsically sustainable society, a step with considerable societal debate.

As our sustainable development agenda aligns with these phases, it consists of three innovation tracks. This is because the first two phases are already done and dusted. The latter three will take the lead in our innovation strategy: the very short term, the short-medium term and the medium-long term. They correspond with three *Innovation Tracks* that will support and accelerate these phases coming into being. In short, they are called:

Innovation Track 1:	Recycling
Innovation Track 2:	Circularity
Innovation Track 3:	Intrinsic Sustainability

Innovation tracks 1 and 2 will be devoted to problem-limiting strategies, and Innovation track 3 will be devoted to the final step: developing intrinsically sustainable solutions and thus radically solving the packaging dilemma (see Chapter 1).

The three tracks in parallel offer an innovative realisation strategy that accelerates our common journey towards an intrinsically sustainable society *(see Figure 15)*. During this journey they cater to different societal needs, from the very short term and being concrete to the longer term and being pioneering exploratory (but urgent nonetheless). Although all three Innovation tracks are started simultaneously (have started already, albeit cautiously in case of Innovation track 2 and especially 3), their dominance changes over time. Innovation track 1 is dominant on the very short term, Innovation track 2 will become dominant soon during the medium term, and Innovation track 3 takes the full lead on the medium-long term. However, in handing over the dominance, the main features of earlier tracks are being preserved in subsequent tracks. In Innovation track 1, recycling and efficiency of packaging resources are key. When Innovation track 2, with a diverse spectrum of circular principles operating on the level of the integral production-consumption systems, takes over, recycling and efficiency of packaging resources will remain important and will be included. Innovation track 3, finally, will look at our societies as a whole as object system, and will innovate and improve at those levels and scales that are required to realise intrinsic sustainability. This includes and encompasses the scope and goals of Innovation tracks 1 and 2 *(see Figure 16)*.

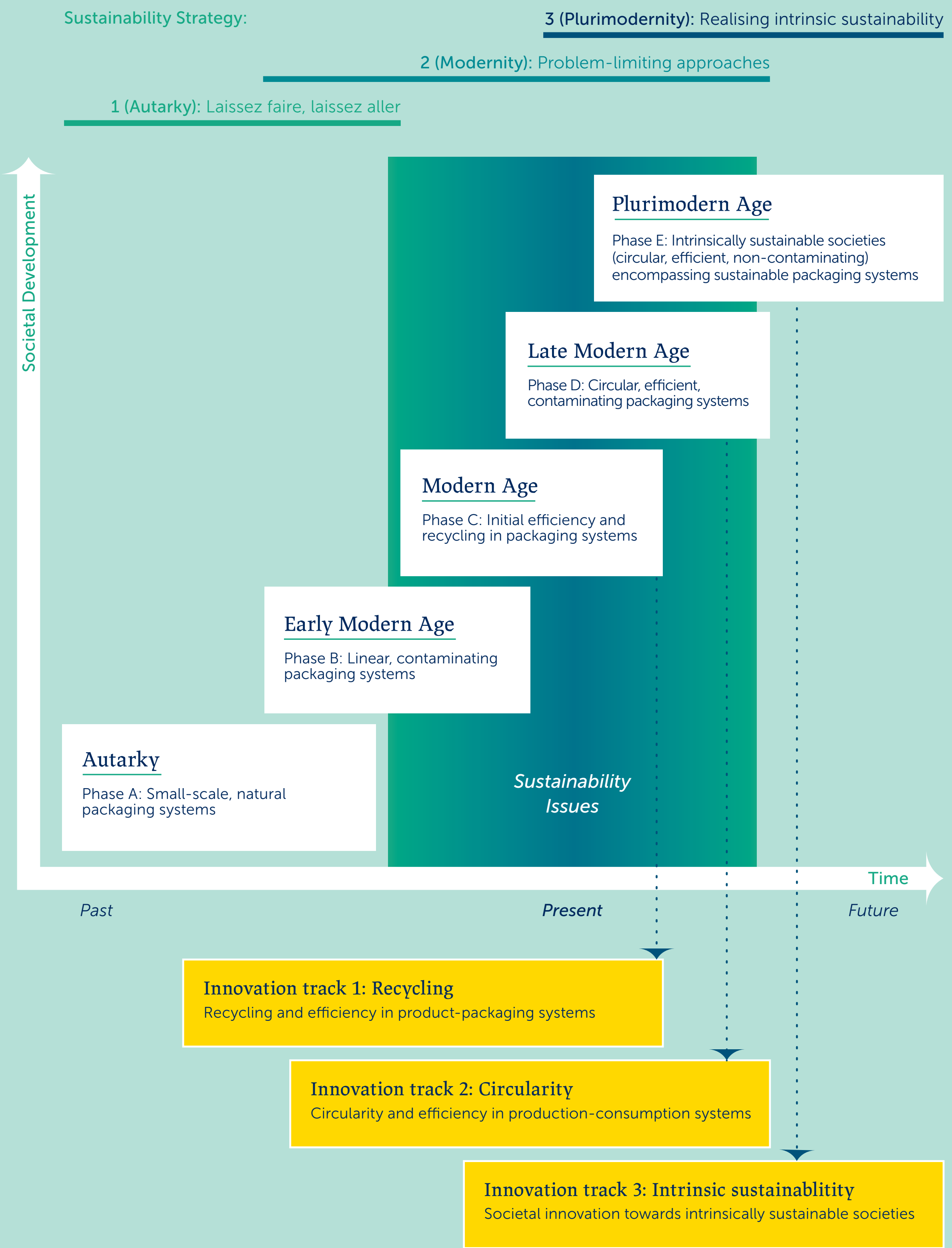


FIGURE 15 - INTEGRATION OF THE INNOVATION TRACKS.

"Building a strategy around the circular economy on its own is not enough, you need to combine a number of approaches that prioritise using less, not just driving circularity around disposable, wasteful systems."

Tracy Sutton,
Founder and Lead Consultant at Root,
The United Kingdom

3.3 The three tracks in some more detail

Each of the three innovation tracks is characterised by a different culture, players in the field and different combinations of innovation methods. They are initially described below:

Innovation track 1: Recycling and efficiency in product-packaging systems

Innovation track 1: Recycling and efficiency in product-packaging systems, operates on the very short term. It is characterised by far-reaching recycling and efficiency, here and now, and is already in full swing in forerunning countries. We must quickly improve the recycling rate of packaging waste and boost efficiency even further, for instance through integral product-packaging design, further dematerialisation, and reducing the variety and complexity of packaging materials in use in order to obtain a sufficient economy of scale.

Innovation spearheads in this track are (not complete):

Conceptual:
- extending the potential of and making more flexible existing recycling systems
- bringing together the notions of "fit for purpose" and "fit for recycling" resulting in "design for recycling"
- reducing the variety of packaging materials to mono materials while maintaining functionalities
- less polluting or disturbing additives
- ...

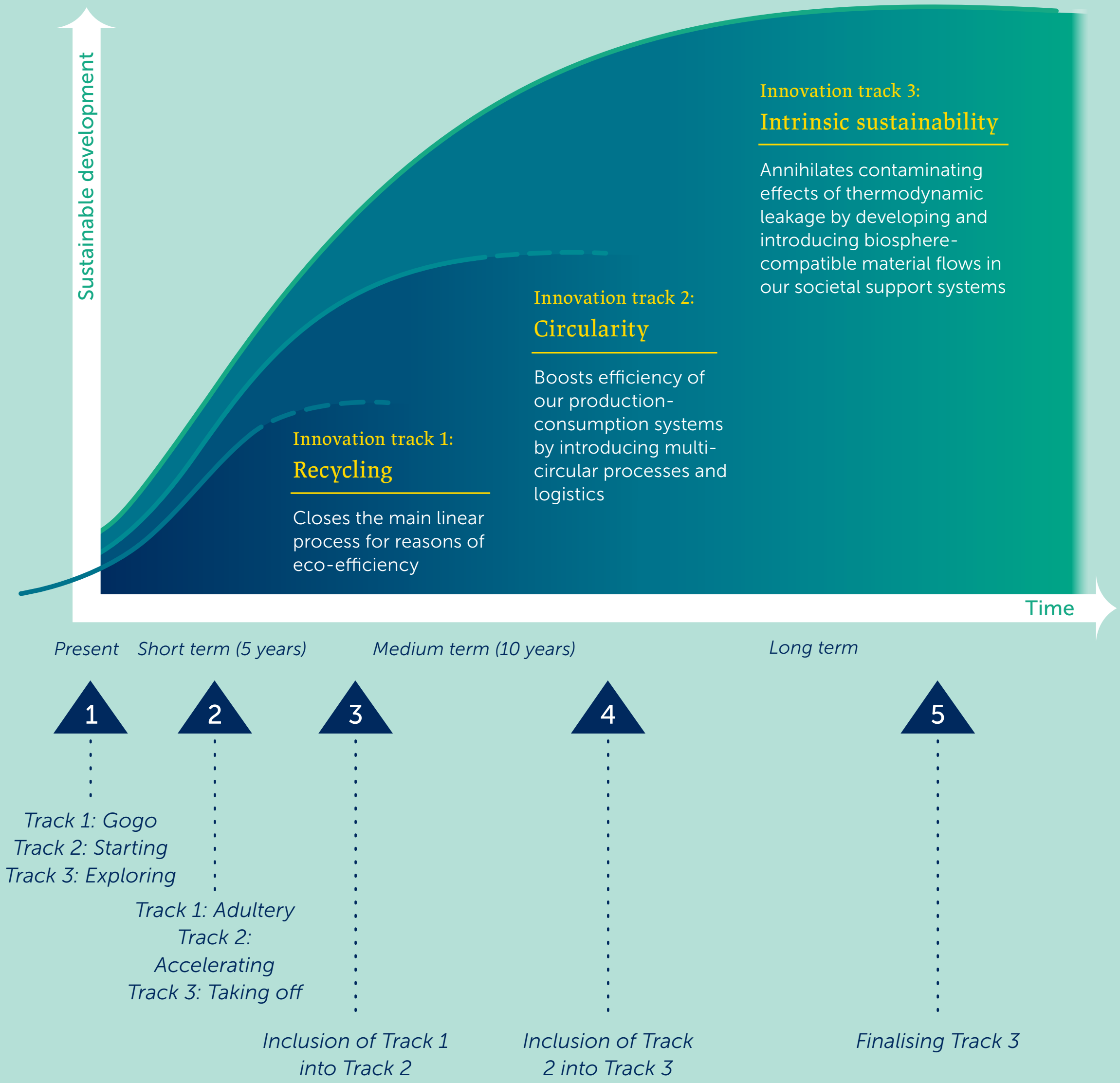


FIGURE 16 - SOCIAL DEVELOPMENT, SUSTAINABILITY STRATEGIES AND INNOVATION TRACKS IN TIME.

Innovations targeted at improving specific stages:

- collection of waste (Post Consumer with or without separation in households, or Post Industrial)
- sorting of packaging waste from different collection streams
- reprocessing of waste to recyclates or new molecules e.g. by means of chemical recycling
- new opportunities for using recyclates
- dealing with additives
- ...

THE NEW NTCP PLANT (NETHERLANDS TESTCENTRE CIRCULAR PLASTICS)

Practical:

- tests of the above, firstly under pilot conditions and in pilot factories
- upscaling new sorting and recycling technologies
- practising design for recycling with suitable guidelines
- ...

In this way we will slow down the most urgent and visible manifestations of the packaging waste problem (track 1 focusses on problem limitation).

Innovation track 1 is the primary responsibility of producers, importers, recyclers and packaging specialists. *Box 11* gives an example of a current innovation track of flexible packaging. Governments have a supporting and enabling function (legislation and co-funding). The innovation method of preference is product-packaging and process innovation with additionally a strong emphasis on the two multi-actor methods of innovation (3. Team optimisation and 6. Coalition building).

Box 11: Innovation of flexible packaging

Flexible metalised packaging like crisp bags are currently hardly recycled in Europe. Therefore, a consortium of companies cooperates to design a Roadmap towards increased recycling of these types of packaging.[27]

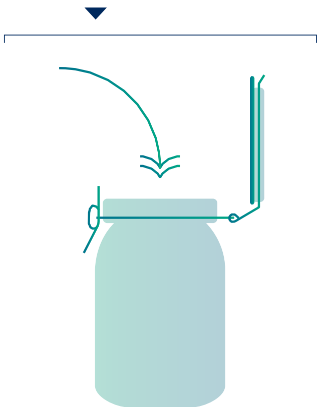
Innovation track 2: Circularity and efficiency in production-consumption systems

Innovation track 2: Circularity and efficiency in production-consumption systems operates on the short-to-medium term (say from now to a decade). We must transition towards a circular economy that covers all available circular principles and emphasises efficiency to an even greater extent, thereby adding to the problem-limiting efforts of track 1 to a considerable degree. To do so, we will have to rely on the middle steps of the ladder, which revolve around intra- and inter-loop efficiency. The target system in track 2 is the complete production-consumption system, which will encompass far more possibilities for closing loops than merely recycling waste at the end.

An intense circularity will require a very high proficiency in logistics, as not only the linear economy of former times is turned into a single loop, but many in-between loops will be introduced as well, at higher value levels, in order to decrease the use of raw materials and the leakage of contaminating waste to a minimum. Optimally, innovation track 2 reduces the leakage of contamination to its thermodynamic minimum. Practice will have to tell where the pragmatic minimum lies. The current recycling rates of forerunning countries are telling in this respect: enormous steps are still possible in contrast with linear economies, especially in developing countries, although this will not be sufficient to solve the dilemma.

The focus of track 2 innovation is the complete production-consumption system. As a result, the primary players in the field will increase to all the parties involved in (turning highly linear systems into) multi-circular systems. Producers and importers will participate intensely, but will not be able to steer the innovation processes anymore: these processes involve multiple parties by nature, involving complex return processing and logistics and its changes will influence retailers, logistic parties, consumers, recyclers, refurbishers, ... This will drastically influence the culture and the type of methods of the innovation processes. Technology will remain as important as before, but in addition to this a lot of effort will have to be directed at the multi-actor nature of the processes.

Innovation track 2 has already been set in motion in terms of initial pilots and even societal practices, and we are starting to see initial results. The innovation coalition of concern in these pilots is determined by the specific form of circularity that is being developed and introduced. So far pilots mostly act on only one cycle (e.g. smartphones or supermarket products). Multi-circular innovations are expected as well, for example packaging designs that, after multiple re-use, will be fit for repurposing in other contexts. The innovation track has started already, albeit cautiously. In order to manifest its effects on the medium term, it should accelerate in the very near future.



"The puzzle to close the cycle is complicated. Paper cannot be recycled endlessly, new paper fibres are always needed. The question is what more can be done, for example with reusable packaging. We are investigating a number of pilot projects (...). In theory a lot is possible, but putting it into practice is not that simple."

Frans Falize,
COO at Wehkamp,
The Netherlands

Innovation track 3: Societal innovation towards intrinsically sustainable societies.

Innovation track 3: Societal innovation towards intrinsically sustainable societies, will have its operational effects on the long term (years to decades). It is the most ambitious of the three tracks, as it both encompasses and supersedes the problem-limiting methods and goals of the first two tracks. There is an end to problem-limiting strategies. As billions of people will be enjoying the benefits of our modern economies in highly distributed and divergent ways, closing the loops 100% is simply not feasible due to practical and thermodynamical reasons. Leakage cannot be avoided, will accumulate and become problematic (see Chapter 2, *Box 5*). The contamination of our biosphere will be slowed down by the problem-limiting Innovation tracks 1 and 2, but it will be progressive nonetheless.

Precisely this is why Innovation strategy 3 is indispensable. It questions the intrinsically unsustainable nature of the material flows that are passing and circulating in our current production-consumption systems. These material flows will have to change from biosphere-incompatible and contaminating into biosphere-compatible and non-contaminating. This crucial and challenging step finally will radically solve the packaging and sustainability dilemma.

At this moment it is not clear what type of societal innovations and exact changes in material flows this will require and bring about. Bio-sourced systems and compostable packaging alternatives are at the heart of severe sustainability discussions. They are sometimes banned by contemporary recyclers, because they are incompatible with the current recycling processes. This slows down further innovation in track 3, as on the long run they may be the best candidates for biodegradable material flows and therefore for intrinsically sustainable support system design. That this development does not cause rebound effects needs to be watched however, as people might simply discard of their waste in their direct environment: "Why not, it's biodegradable, isn't it?".

Modernity's enthusiasm for increasingly larger scale societal support systems (like food supply) may become more balanced: these systems may operate on several societal scale levels in the future (plurimodernity). En passant the reasons for operating in highly circular modes will change. They are likely to change from efficiency driven (the main reason in the past) via environmentally driven (the additional reason during Modernity) into efficiency driven once again (the likely reason in Plurimodernity).

Our future is hidden in mist, but our transition towards intrinsically sustainable societies is unavoidable, given the growth and development of both our economy and the number of individuals that maximally enjoys its benefits. Therefore, is it important to kick off this innovation track 3 in a full-blown manner, as we will have to prepare for the shift towards an intrinsically sustainable system of production-consumption including packaging as soon as possible, in whichever way we will realise this last step. The circular and efficiency principles of the former two Innovation tracks 1 and 2 remain important, but the existing material that flows through our production-consumption systems will be challenged and changed. This represents the two highest steps of the ladder: *Rethink* and *Refuse*.

In terms of the incumbents in the field, innovation track 3 is the most ambitious one: on top of and in the place of the functions and roles of existing parties, new functions and roles will have to be explored and designed and new technologies are required. In terms of innovation, all three axes and all six innovation principles of the innovation cube are at play intensively and the amount of players in the field is extensive. Innovation track 3 is still in its premature days with tentative initiatives cropping up here and there. It is important that it is catalysed quickly. At this moment it is unclear who is taking (or better who is able to take) the lead.

3.4 PackForward needs an engine

This chapter presented a first sketch of a threefold innovation strategy for packaging for sustainability and our quest for an intrinsically sustainable society. This strategy combines recycling, multi-circularity and intrinsic sustainability. Many activities have started already, some companies and governments are even ahead, but further progress on all three frontiers is both important and urgent. It is a package deal.

For this reason, efforts in innovation track 1 will have to be intensified and combined, efforts in innovation track 2 will have to grow to maturity as soon as possible, and innovation track 3 should be ignited and catalysed further as soon as possible.

In the near future, a more detailed version of this ambitious threefold innovation vehicle, sketched above and named PackForward, will need to be worked out. A key question will be how to accommodate this vehicle with an appropriate engine. What type of body will be able to promote, guide and even steer this parallel transitional innovation process, involving proactive and voluntary participation of governments, companies, citizens-consumers and universities at the societal scale?

3.5 Final advice

This leads to one overall advice, at the end of this State of Sustainable Packaging. It is as simple as that it is ambitious. Intrinsic sustainability is a *sine qua non* for our future. We propose, therefore, to put the threefold innovation strategy into motion in a structural way, in all three interdependent tracks, as soon as possible. In doing so, we should make use of the most relevant insights, activities and parties that are on the way already. A first step is to draw up a societal master programme that meets the demands sketched above, and requires an active role for all the societal parties involved. This is important as society needs packaging for sustainability.

An introduction to:

PACKFORWARD

The European network for sustainable packaging

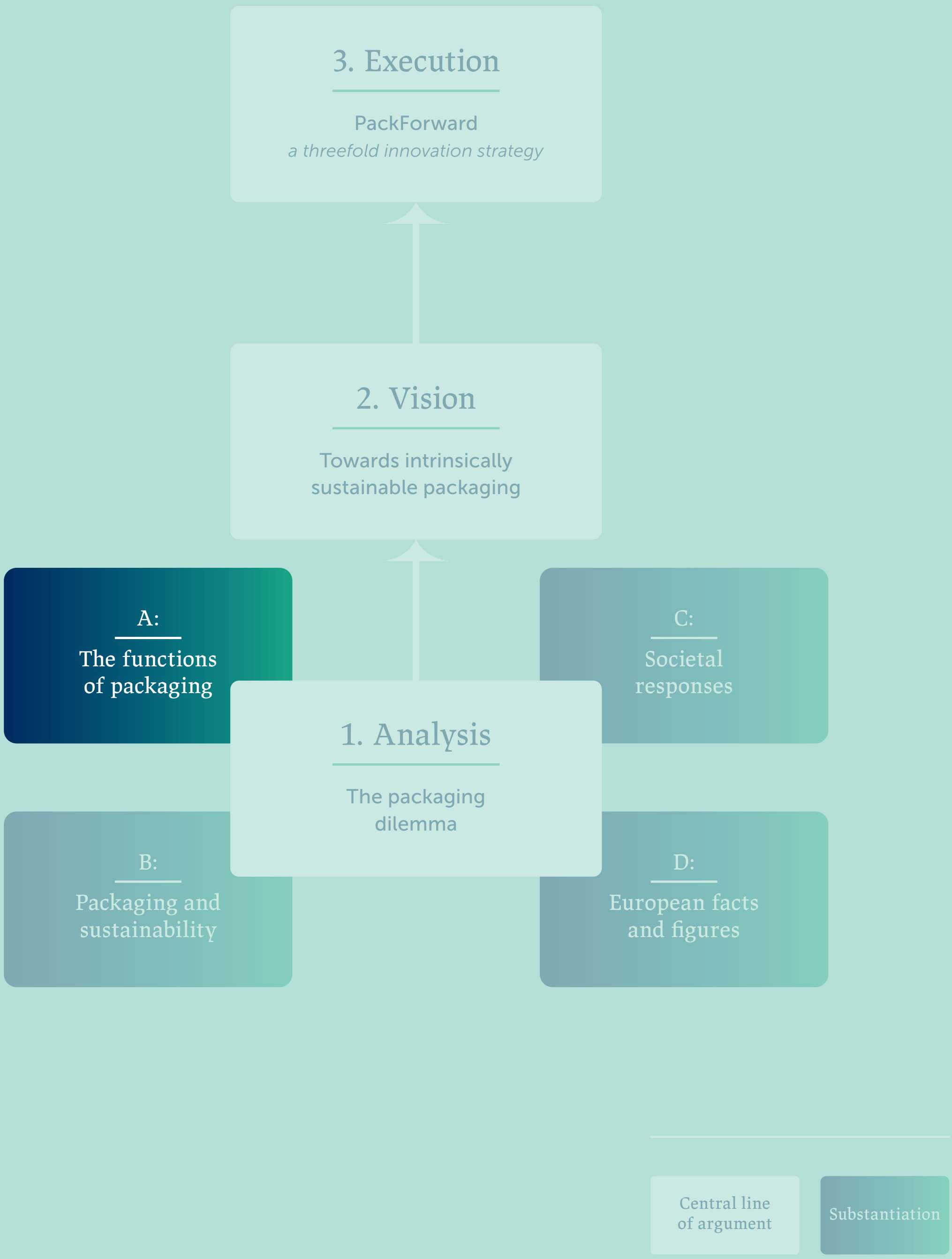
PackForward supports stakeholders in the packaging value chain to increase sustainability. The packaging industry needs dynamic services and knowledge at a European level. Network partners share their best practices and projects and make their knowledge widely accessible. Next to that, PackForward provides an overview of important themes that affect the sustainability of packaging: from the production process and use of product-packaging combinations up to the waste stage.

PackForward can create an effective network to stimulate coherent actions on the three innovation tracks in *The State of Sustainable Packaging*.

The Netherlands Institute for Sustainable Packaging (KIDV) together with partners Fost Plus, Gront punkt Norway and Valipac are the initiators of PackForward and will continue to strengthen it together with other organisations.

Learn more at packforward.eu →

Fostplus · Netherlands Institute for Sustainable Packaging · Grønt Punkt Norge · valipac


3. Execution
PackForward
a threefold innovation strategy
2. Vision
Towards intrinsically sustainable packaging
A:
The functions of packaging
C:
Societal responses
1. Analysis
The packaging dilemma
B:
Packaging and sustainability
D:
European facts and figures
Central line of argument
Substantiation

Chapter

The functions of packaging

A

A.1 Introduction

Packaging is used because of its functionality. The growing desire for more sustainable packaging will however not only affect packaging itself, but also the packed product and the combination of the two. This chapter introduces the nexus of product and packaging and explores how we came this far. Key issue for packaging is functionality. The notion that “the best packaging is no packaging” appears to be patently false in the vast majority of packaging solutions.

A.2 A brief history of packaging

Packaging is as old as mankind, as an answer to the need to store and transport food. Hunter-gatherers, followed later by farmers, already relied on packaging in order to preserve, because harvest seasons were rarely year-round and once an animal was slaughtered, the meat needed, like the yield, to be preserved quickly to stop decay. In addition, food also needed to be preserved and packaged, in order to be able to trade it. Initially, food was transported over small distances, from one village to the next, but when the distances became greater, the quality of preservation and packaging needed to improve as well.

The need for efficient transport was already clear in antiquity, as proven by the imbricate stacking method used by the Greeks to transport amphorae in ships, or the hexagonal glass bottles and, as found in Pompeii, square wooden crates filled with bottles used by the Romans. The ancient Greeks developed measuring systems to determine the capacity of amphorae and used stamps to communicate the volume, weight and authenticity of their wares. Not all that different from today’s packaging. The functions of packaging have basically been the same for centuries: portioning of a certain amount of product, preserving and protecting food, facilitating, distribution, and optimising transport and conveying information. For centuries, markings and labels have been used to guarantee the volume of packaging for the sake of fairness.

French chef Nicolas Appert discovered that hermetically sealing heated food dramatically increased its shelf life; he preserved his food in metal cans that were soldered shut and in glass jars. With this innovation, Appert won a prize awarded by Napoleon, to those who developed a new method to improve the battlefield rations of his army. Appert used the money to open one of the first food preserving factories. The early 19th century is, till today, seen as the cradle of today's methods of industrial packaging, with the Industrial Revolution boosting the large-scale production of packaged foodstuffs. The distance between producers and consumers increased, to the point that producers no longer knew who was actually buying their products.

In the 19th century, pre-packaged food was out of reach for the majority of people, because it was too expensive. Over the course of the 20th century, economic growth ushered in an age of prosperity and new knowledge, leading to a less expensive large-scale production of packaged foodstuffs, making it available to the masses.

The daily groceries from greengrocers, butchers and bakers, insofar as they were not delivered directly to their doorstep, made their way to the supermarket. Butcher shops moved into supermarkets, initially as a shop-in-shop concept with separate tills, which would often lead to long queues. As a result, the popularity of pre-packaged meat skyrocketed, especially after the innovation of so-called Modified Atmosphere Packaging in the early 1990s, which involves substituting the air in the sealed packaging with gas or a mixture of gases, such as carbon dioxide, nitrogen and oxygen, to extend the product's shelf life *(saee also Box 12)*.

Box 12: Ranges of used atmospheres for packaging

Ranges of used atmospheres for modified atmosphere packaging:

- Fatty fish: from 40% CO_2 and 60% N_2 to 60% CO_2 and 40% N_2.
- Fresh meat: 30% CO_2, 30% O_2, 40% N_2. The oxygen level is this high to keep the colour of the meat red, which also keeps growth of micro-organisms low.
- Bakery: 100% N_2.
- Fruit/vegetables: 3-10% CO_2, 1-6% O_2, 84-96% N_2.

A.3 The reasons for packaging

The basic reasons for packaging are the need to bridge time and distance and to convey information, because producers will, generally, not be able to communicate the contents of their products directly anymore. So, the packaging has taken over the place of the grocer and is therefore often called "the silent salesman". Appearance and branding have influenced packaging quite a lot. The basic reasons to pack are nevertheless the quality of a product that can deteriorate over time due to a range of internal and external processes affecting the product. On top of that, transit can affect or reduce the quality of a product. These processes can be divided into the following categories: biological, biochemical, chemical, physical, mechanical and calamities *(See also Box 13)*.

Box 13: Processes that reduce product quality

- Biological: Growth of microorganisms such as bacteria, fungi and yeasts which can lead to quality loss of the product like loss of taste and in the most severe case foodborne infections or intoxications. Viruses can also have harmful consequences for consumers.
- Biochemical: Enzymes in natural products can be activated when the cell is exposed to the outside world. Sliced apple, for instance, turns brown because of an enzymatic reaction.
- Chemical: The most common chemical reaction is oxidation of components such as fats and fatty acids, vitamins A, C and E and flavourings, affecting the taste of a product.
- Physical: Dry products such as crisps and toast can lose brittleness when they absorb moisture. Moist products on the other hand, such as cake, bread and muffins can become too dry. Fatty products and dry leaves are quick to absorb smells in a process known as 'tainting'. Packaging materials used for tea and chocolate, for instance, have to be tested for odour emissions. UV light acts as an energy source in chemical reactions involving oxygen and can have a negative impact on colourants. Static electricity can affect the functionality of electronic chips, as it can burn through minute circuits. That is why electronic products with open components have to be packaged in conductive materials (Electrostatic Discharging Materials).
- Mechanical: Physical processes occur continuously, while mechanical processes occur mainly during transport. Stacking puts a strain on products, of course, but mechanical loads resulting from transport are often greater. Realizing this makes it easier to create tailored solutions in regards to shock-absorption and reduction of energy levels of vibration to the specific chain in question.

- Calamities: Packaging for dangerous goods is designed to withstand any calamities that may occur and must therefore be carefully tested (as is prescribed by law). Since dangerous goods can be transported by air, rail, road and water and across borders, all these forms of transport are covered by both national and international rules and regulations. For other goods a company can take a decision for which occurrences that do not appear on regular base the packaging will be designed: a drop of 80 cm or 1 meter, high humid conditions, theft, rodents etc. This can be seen as risk management but has large influence on the choice of packaging materials used.

A.4 Food packaging

Oxygen

In the food industry, all the processes mentioned in *Box 13* play a role in quality loss, but oxygen is by far the greatest cause of decay. In most cases, oxygen reacts with fats and fatty acids, changing the way a product tastes, in a process also known as rancidification. The thresholds of taste change are critical. Some products, such as certain types of coffee and lager, will taste differently after being exposed to oxygen for just 10 minutes. The packager communicates to the consumer which degree of taste change it considers acceptable by the 'best before date' stated on the packaging. The presence of oxygen also allows aerobic micro-organisms to grow. If reaction with oxygen can lead to foodborne infections or intoxications within five days, packagers must specify a 'use-by date', the final date on which the product can still be consumed. Plastics boast varying degrees of permeability to gas.

Oxygen barriers are rated by the volume of oxygen that migrates through a plastic of a certain thickness per day per surface area (in cc/m^2/day). This rating is a key factor for companies to opt for a specific plastic film. The rating and optimisation of flexible plastic barriers has garnered much attention among scientists and academics. Gas permeability is much less of an issue for thicker, so-called rigid plastic packaging. The most commonly used plastic packaging for primary food packaging are less than 50 microns thick. In comparison, the wall of a plastic bucket is at thinnest about 10 times thicker, at 0.5mm, which means that 10 times less oxygen will migrate through the wall over the same amount of time.

Moisture

Moisture is another important factor, and many materials are chosen because of their specific moisture permeability. For some products, such as respiring products, removing moisture is paramount. At the same time, packaging is also used to be able to neatly store and portion products. This is why fruit such as grapes and cherries are typically packed in PET containers with holes in the bottom. Potatoes, apples and many vegetables are packed in the cheapest plastic available, polyethylene, a material that makes up for being a very poor oxygen barrier by being an excellent moisture barrier. To help remove excess moisture, holes are often punctured in packaging film. Moisture also plays a role in food spoilage caused by microorganisms that need a minimum amount of water activity for growth.

Food contact material regulations

Food contact material regulations are a key piece of legislation.[28] According to the taken up Overall Migration Limit (OML), a maximum of 10 mg of any non-volatile substance can migrate to food per square decimetre, corresponding to 60 mg per kilogram. Specific Migration Limits (SML) apply to substances or groups of substances that are known to be toxic in certain quantities, based on consumption patterns and maximum limits per kg of body weight. Plastics that may come into contact with food must be tested with five simulants. This is the reason that many plastics perform well in practice, of which the same cannot be said of some other packaging materials. Problems such as the migration of mineral oils derived from printing inks and absorbed by recycled paper and cardboard would not exist if the same legislation that applies to plastics also would apply to paper and cardboard.

A.5 Packaging other products

Valuable and durable goods make up the second major category of products to which significant attention is paid to selecting the right type of packaging and packaging material because of the high economic value of the products in question. Packaging costs are generally very low compared to the costs of the actual product, but it is important that the transport volume of the packaged product remains limited. Within the field of packaging, much scientific research has been conducted in determining optimal mechanical buffers, which also has been the subject of many commercial tests. Naturally, preventing transit damage holds great economic importance.

There are myriad products for which the packaging material is based less on specific requirements set by the product, such as office supplies, many Do-It-Yourself products and personal hygiene and care products. Adhesives and paints containing volatile solvents, however, form notable exceptions, as it is important that such products are packaged in materials that form effective barriers. And also product categories, such as plants and flowers, come with specific requirements.

In the case of dangerous goods, the role played by packaging is mainly for protecting the outside world against the product. Depending on the hazard class of the product in question, it must meet certain requirements in terms of storage, transport and use. Packaging therefore, must be tested in accordance with the hazard class and provided with markings and codes specifying the hazard class (UN code), before it can be approved.

Business-to-business products make up another large category of packaged products, and because marketing typically plays a smaller role in this high-volume market, most packaging is designed with an emphasis on protection and economy. High-volume products are typically transported in bulk or in refillable systems, with volumes up to approximately 1,000 litres or kilograms, transported in pallet boxes, big bags and drums. Smaller volumes are packaged in bags up to 20 kg, buckets and so-called pails, cans with a capacity of up to 10 litres. Reusable packaging are often used because of cost reasons and collecting of one-way packaging can be organised rather easy, meaning that recycling rates or rather high in this business sector.

A.6 Trends and drivers

Population growth

Since the advent of industrial packaging in the 19th century, much has changed, especially in the realm of food packaging. Today, we can find hygienically packaged, partially and fully prepared meals with high nutritional values in supermarkets everywhere, whilst spending a smaller share of our income and time on purchasing storing and preparing food. The world has also seen a major growth in population, with the Dutch population for instance increasing from 5.1 million in 1900, to 10 million in 1950 and over 17 million in 2018. This asks for an increase in production. But today's quality packaging also makes it possible for a product to be better preserved and thus travel greater distances to reach more people (of benefit to producers and consumers). As a consequence, this increases the amount of packaging needed.

Using less material

Cutting costs by using less packaging material per product is a continuous development throughout the packaging industry. The weight of glass bottles, the thickness of metal cans, the weight of PET bottles and the thickness of carrier bags have all developed in the same direction over the last few decades: thinner and lighter for the same application *(see also Figure 17)*. The main reason for cutting down on the amount of material used per product, is striving for lower costs and taking better care of the environment. The reason why this has not been done before is that process control is improving, infrastructure and transport means are optimised and cause less vibration and shocks, replacing expensive tooling is mostly only done after return on investment periods of ca. 10 years.

FIGURE 17 – THE AMOUNT OF GLASS USED PER LITRE OF WINE SOLD IN THE NETHERLANDS IS DECLINING. FIGURE IS MADE BASED ON [29]

In a nutshell, the past decades of development in the world of packaging can be summarised as a constant reduction of the amount of packaging used per product, combined with an increase in product quality and volume that have greatly reduced the amount of time people spend on housekeeping, storing food products, purchasing meals and cooking.

"What I know for sure: the less material the better, the more recyclable the better, as less as movement as possible is better. Less is more!"

Frans Falize,
COO at Wehkamp,
The Netherlands

More portioning

The emergence of ever-increasing portioning, however, seems to be bucking this trend, as smaller quantities of food are packaged in convenient, single-portion packaging. Although this increases the amount of packaging per packaged volume, this development does reduce food waste and answers to social developments, such as the increase in the number of one-person households.

More functionalities

Another important development is that packaging incorporated a wide range of new functionalities to increase user convenience. Examples are aerosol cans for store-bought whipped cream, for instance, see-through windows in juice cartons for portion control and single-portion, ready-to-eat packaging; developments that offer everyone the opportunity to tailor to their specific needs. Easy-to-open packaging is also set to become a key area of attention, partly because of the ageing population, which will see the development of solutions requiring more material, such as larger pull tabs or wider grips.

Appearance of the packaging and the battle in the shop

Innovations in the field to distinguish the packed product are continuously being introduced throughout the years. Examples are very thin layers of deposited aluminium, high definition printing techniques, high gloss or matt surface effects, a pearl surface appearance, highly transparent windows, no label look by transparent labels etc. Packaging designers adopt these techniques usually very fast and marketers are often proud to be the first to have brought a new appearance to the market, looking at the many design competitions in which appearance plays the most important role. Introduction of new techniques is mostly done by A-brands and the years after the techniques get available for other brands. Being seen in the shop is of large importance for sales because brand loyalty of consumers is decreasing which means that the design of the packaging is becoming more important. The choice for a certain brand is for some category of products for over 50% made in the shop. Marketing has therefore a major influence on the material choice as research showed[30] and the focus is often on appearance and influencing buy decisions by the consumer. This also can be seen on claims made on packaging like “made with bioplastic” if only a very small amount of biobased polyethylene is added to the used material. Convenience is an aspect that also is used to distinguish the packed product. Easy opening, dosing, ready made creams etcetera can boost sales. They often ask for more material use.

The rise of plastic

The world of plastics has seen tremendous development, as this material lends itself perfectly to the production of incredibly thin foils that can quite easily be laminated. As such, an ideal layer can be found for each required function; a layer for printing, a layer as gas barrier, a layer for strength and a layer for sealing, all in thickness ranging from 15 to 90 microns. Even PE carrier bags, for instance, are made up of several layers of different types of PE suited to a specific function, in what is also known as ‘tailoring the molecules’. Today, producers can match molecules to functions and vice versa, explaining the enormous growth of plastic.

Year-round availability

The growing economy and increasing prosperity has created a large global market for food. We can eat fresh strawberries and cherries all year long and previously unknown vegetables such as aubergines have become common. We sometimes don't even need to import them, as they can be grown in greenhouses as well. Many products however are transported over long distances, prompting the development of rather efficient systems. Thanks to the increase of global travel, we know, want and buy more exotic products than ever before, and yet the part of our income we spend on food has decreased. In *Box 14* an example is given of the role of packaging in the case of a cucumber. *Box 15* highlights the trends and their consequences.

Box 14: The role of packaging for a cucumber

There is probably no type of packaging that has been more hotly debated in recent years than the shrink-film used for the humble cucumber. Increased global prosperity, research and development have brought us to a point where we can enjoy cucumbers all year long at an affordable price. The cucumber originates from India and cannot grow at temperatures below 15°C, which is why, in the Netherlands, cucumbers are grown in greenhouses or are imported from warmer countries. Depending on the amount of time these cucumbers spend in transit and the temperature they are stored at, foil can increase their shelf life. Growers would not spend thousands of euros on film if it did not serve a specific purpose. Especially in winter, when cucumbers are grown in gas-fired greenhouses, film plays an important role in protecting these vulnerable fruits. In an optimised transport chain, featuring heated storage and misting machines to stop cucumbers from drying out in the supermarket, it would be possible to sell cucumbers without film. Although consumers would have to realise that this would still reduce the shelf life after purchase.

Box 15: Key trends and consequences of prosperity

Key trends:

- Less time spent on storing and preparing food.
- Fewer shopping trips.
- Fresher, higher-quality, better-tasting products.
- More products packed in portions.
- Lower costs, thanks to the continuous optimisation of use and functionality.
- Social media, posting pictures on Instagram and the appearance of the product affects the choices people make.
- Higher focus on appearance of the packaging.
- Convenience and more functions taken up.
- Growing population worldwide.
- Ageing of the population.

Consequences of prosperity:

- More money spent on food and products.
- A smaller part of the income spent on food.
- International travelling increases familiarity with different types of products and food.
- International travelling stimulates the emergence of a global marketplace for products, exotic food and dishes.
- Fresh fruit and vegetables are no longer seasonable products, but available all year round.
- Due to the high level of availability offered, we are less aware of where products come from.

A.7 How much packaging do we use?

Packaging is a necessity for many products, which has only increased as a result of expanding global trade and transport of goods. The amount of registered packaging material developed in recent years can be linked directly to economic growth. In 2017, the average Dutch consumer used approximately 400 grams of packaging a day, of which 65% for food packaging *(see Table 1)*. However, this number only reflects the amount of primary packaging used and does not take cardboard boxes, trays and plastic crates into account. Using profiles of daily consumption, eating patterns[31] and household surveys, we assessed the accuracy of this finding. When buying as much fresh produce and reusing as many bags as possible, the average consumer can use less than 100 grams of packaging material per day. As soon as fresh produce is replaced by pre-packaged food, however, the amount of packaging material used per day per person skyrockets to 800 grams per day. Boxes used for delivery pizza only weigh 80 grams and score well in terms of the total amount of packaging used for a hot meal compared to preparing a meal with pre-packaged food.

Gram per inhabitant per day	2013	2014	2015	2016	2017	2018
Glass	88	86	81	81	80	80
Paper and Board	196	190	198	202	202	198
Plastics	76	77	80	81	82	83
Metal	33	36	33	33	35	34
Total	394	389	392	397	399	395

TABLE 1 - INDICATION OF THE AMOUNT OF PACKAGING MATERIAL USED PER INHABITANT PER DAY IN THE NETHERLANDS.[32]

Where are the experts?

Companies can be expected to track how well their packaging does perform in practice, assessing whether their packaging should be made sturdier to limit transit damage, for instance, or scaled back because damage is so rare. Similarly, they may want to monitor customer complaints and explore whether too much of the product remains in the packaging after use, in order to optimise the nature and quantity of the packaging material used. Technological tools, such as simulations, modelling and tests (for instance transport simulations and box compression tests), can also be used for this purpose. It goes without saying that companies responsible for selecting the most suitable packaging for an application should have access to this technological knowledge, but in practice it appears that in-depth knowledge on packaging is scattered about many different parties, and no single one is single-handedly responsible for selecting the right packaging material. This lack of (shared) knowledge and insight among packagers is an obstruction in the quest to develop more sustainable product chains. The attention to structural packaging design is far less than on packaging design that focuses on the appearance, often called graphical packaging design.

Legislation: a paper tiger?

According to the Packaging Waste Directive, European legislation on packaging adopted in 1994 (EC 94/62), each unit of packaging must contain the minimum amount of material possible, taking hygiene, safety and consumer acceptance into account. Based on EC 94/62, producers can justify the use of a certain amount of packaging material with a range of rational explanations, but more debatable factors, such as market position and brand perception can also play a role. Consumer surveys, for instance, show that the appearance of the packaging influences the judgement of premium quality.[33,34] Also the weight of packaging is associated with quality, as Ilja Gort showed in his tv program[35] when people had to pour wine from a bottle to taste and evaluate it. The wine from the heaviest bottles was perceived as the best wine: a thicker, heavier or sturdier packaging can give the impression of premium quality. Companies can then use these psychological factors to give their products a more luxurious appearance, thereby justifying a higher price and a larger margin. Companies can defend such practices by referring to the customer acceptance criterion in EC 94/62, despite the fact that it was originally included in the Packaging Waste Directive in order to cover gift packaging and should therefore not be used to explain or defend other types of packaging. But who could assess and enforce this and thus tame this paper tiger?

Cost considerations

Analyses performed on the basis of figures of major food companies[36] have shown that the costs of all packaging used is approximately equal to the costs of the packaging process. The process, here, encompasses everything that is needed to get the product into the packaging, from the machines, the people, energy and water, to buildings and storage space, insurance, etc. The cost price of a unit of the packaging itself can be determined on the basis of key figures like the weight of the packaging or the surface area of said packaging when using techniques such as higher-quality printing machines, corrugated cardboard or laminates. A more complex approach to calculate the costs of packaging also takes into account raw materials, human-machine costs, costs for tools such as moulds or dies, overheads, etcetera and can be used to make differentiation within the field. On base of key figures it can be stated that approximately 50% of the cost price of a unit of packaging goes into raw materials. Packaging materials are relatively cheap production materials compared with other engineering materials: glass is made of sand, steel and aluminium are among the cheapest metals available, polyethylene, the most commonly used plastic in packaging, is made of ethylene, a petrol waste product, and paper/cardboard is made of those trees or part of trees that cannot be used for furniture and construction. These materials are not expensive. From a production perspective, glass is an exceptional case because of the absence of any intermediary: glass is made and immediately formed into a unit of packaging in one single process. The production processes for all other packaging materials involve intermediate steps.

In packaging being a high-volume industry, with millions of units being produced on a daily basis, efficiency is a major factor in reducing costs and in reaching the amounts demanded by the market.

Cost price means the amount of money paid to the producer. Cost prices are in practice mostly presented per 1000 pieces like 29.60 €/00, and not as 2.96 cent per piece. Remind that these prices are only for the standalone products as mentioned. A bottle needs a cap and a label or sleeve, and has to be transported in a carton box or tray, with tape and labels. The total packaging costs will therefore be higher than presented in *Table 2*. The share of raw materials in cost prices of packaging determine ca. 50% of the final price, for high numbers this can go up to 70%.

The hypothetical case study in *Box 16*, which is based on figures published by the beer industry[37] shows the inherent difficulty in balancing costs and profits and highlights how minor details can impact the big picture. As a result, packagers and packaging producers are under constant pressure to keep costs low, which - given the direct link between cost and amount of material - means that a lot of packaging is optimised from the point of view of costs and amount of material used. As such, the packaging chain is based on indices and has seen widespread optimisation, limiting the scope for change.

Box 16: An example of cost and profit effects as a result of minor details in the beer industry

Suppose a beer producer with a turnover of EUR 1 billion made a profit of EUR 80 million in 2017. This represents an 8% profit margin, which is feasible in this sector, where the turnover per employee is somewhere between EUR 250,000 and EUR 300,000 for premium brands. Assuming that this is a major producer, we can estimate that this turnover stems from the production of 10 million hectolitres of beer, translating to a profit of 8 cents per litre. Now if, hypothetically, all this beer was sold in 0.3-litre bottles, the producer would make a profit of about 2.4 cents per bottle. This means that if a designer were to make a cap that costs 1 cent more, 40% of total profits would evaporate, unless the new cap has added value that allows the producer to sell its beer at a higher price. To make up for these extra costs, the seller would have to hike up its prices by 2.2 cents per bottle or more than 50 cents per 24-bottle crate because prices are doubled, and taxes have to be added for consumer sales.

Packaging item	Key parameters	Price information	Examples with estimated prices
Glass bottle	• Glass weight • Colour • Details in shape • Large volumes needed to break costs of moulds down	• White (flint) is most expensive. • Brown is middle priced. • Green glass is cheapest. • Long bottles (tall) can cost 15% more.	• White glass bottle, 1 litre for juice, basic shape, 500 grams, ca. 23 eurocents. • One-way brown beer bottle 0.3 litre, 300 grams, ca. 12 eurocents. • One-way green bottle condiments, hot fill, 0.2 litre, 180 grams, 6 eurocents.
Plastics	• Flexibles, printed in quality print, based on surface area.	• Square meter prices from 0.08 euro to 2.50 per m2, depending on number of colours and film type.	• Small sachet for sauce with barrier: 3 cents. • Bag for crisps with high quality printing: 6 cents.
	• Flexibles (bulk, like pallet film, plastic bags, shrink film etc.), bottles and rigid articles based on weight.	• PET bottles are made out of a preform which is injection moulded. The final bottle is often produced (blown) on site at the filler.	• Small PET bottle 0.5 litre, 20 grams, ca. 5 cent. • PE bottle for shampoo, 0.2 litre, 24 grams, ca. 5 cents. • PE shrink film, weight 20 grams, ca. 4 cents. • Plastic bag, 12 grams, ca. 3 cents.
Folding board boxes	• Surface area is key parameter.	• The printing technique (flexography, offset, gravure) and the number of colours are important indicators.	• Small box for three sachets of (powder) soup: 4 cents. • Carrier for 6 glass bottles: 15 cents. • Box for cereals: ca. 30 cents.
Corrugated boxes	• Surface area is key parameter.	• The type of flute (B, C, E, F, BC etc.) and the choice of liners are determining the price.	• A corrugated box of ca. 300 x 400 x 200 mm (WxLxH) costs ca. 32 cents.
Metal packaging	• Weight is most determining factor. • There are different steel types. • Aluminium for cans and tops are different alloys.	• Two types of cans can be distinguished: 3-piece can with top, body and bottom and 2-piece can were body and bottom are made out of one piece.	• A metal can with a 1-litre volume: ca. 15 cents. • A beverage can: body and top together ca. 12 cents.

TABLE 2 - COST PRICES OF A FEW PACKAGING EXAMPLES

A.8 What's next?

The gap between the environment and the economy

Professional, functional packaging is a *sine qua non*, but so is a healthy environment. Until recently, the growing scale and professionalism of functional packaging saw its environmental footprint rise steadily due to blind progress, causing the gap between the economy and the environment mentioned in the introduction. The challenge is to continue to develop packaging in order to meet both sets of preconditions, both functional and environmental. To get a grip on this challenge, the following chapters will first delve into the environmental side of the matter, before exploring how the Netherlands and Europe are currently dealing with this issue and synthesise the whole in a strategic vision for the future.

"A design strategy to use less resources in a more responsible way throughout the defined lifetime of a product or service, is rarely realised. Packaging experts with a technical background generally go granular: they add recycled content, they make it recyclable (which it should be at a minimum industry standard) and we add a mobius loop symbol to a label – which tells a customer nothing. These details do not lead to a long-term strategy to reduce resource use or reduce climate change."

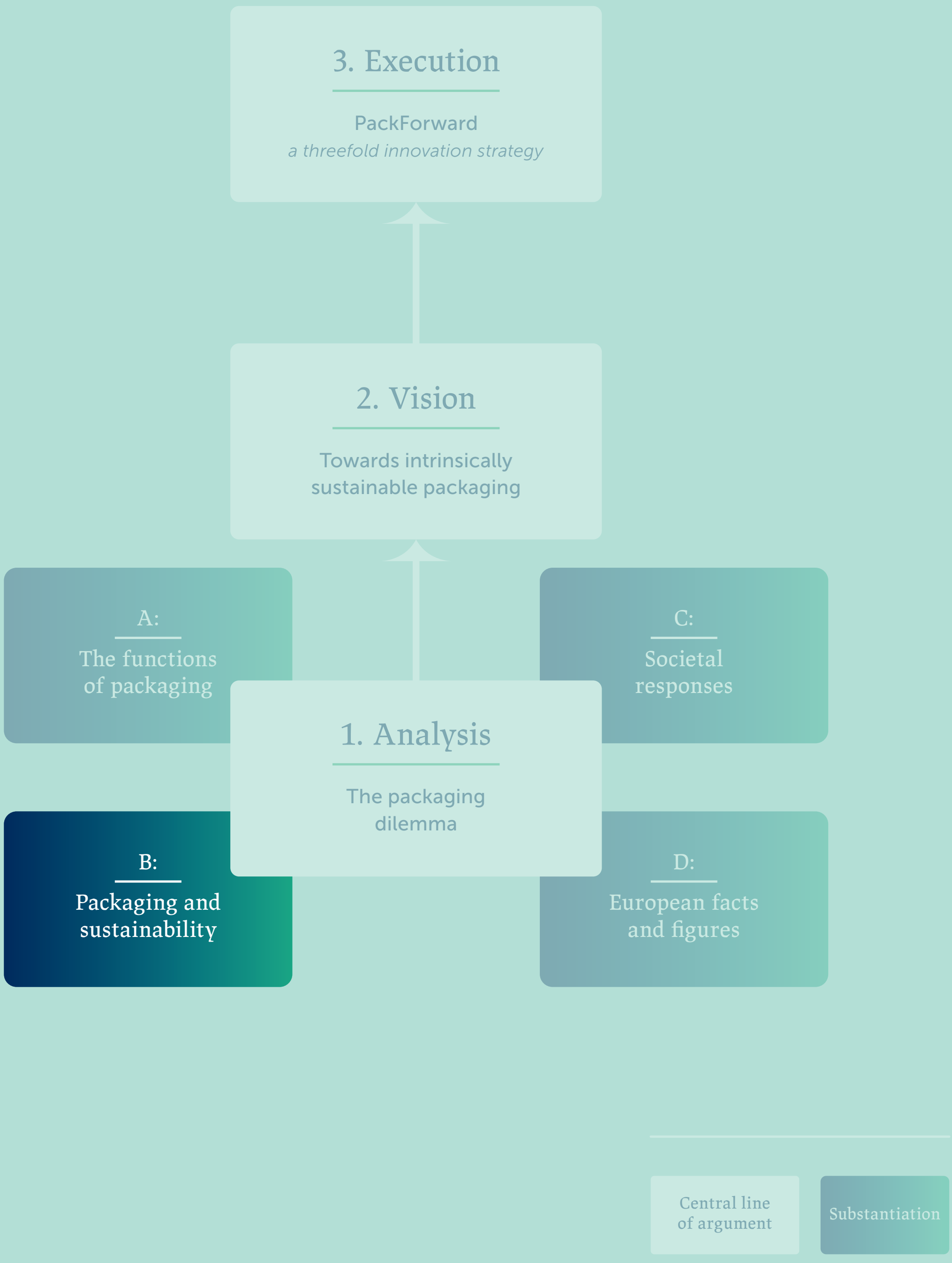
Tracy Sutton,
Founder and Lead Consultant at Root,
The United Kingdom

Circularity bites back

Recycling and circularity have a major role to play in bridging the gap between the environment and the economy. However, we can already state that, especially when it comes to plastics, the current trend of using less packaging will interfere with the transition towards a circular economy. Keeping material in the chain now seems to be more important than society's carbon or water footprint, conflicting with the trend of reducing the amount of material used per unit of packaging that served as the foundation of sustainable development over the years. Today's highly efficient solutions based on laminated plastics are often poorly recyclable, which puts multi-layer packaging material in a tricky position. The sheer number of different plastics available poses another problem, and though there may be a limited number of base types, there is tremendous variety to be found within them. Average polymer chain length, distribution of chain length, the use of additives and lamination all complicate the matter of recycling materials into the same level of quality. This, however, does not mean that plastic-based solutions cannot be circular to a larger degree. A focus towards harmonising the types of plastics can raise recycling rates and new forms of recycling emerge, such as chemical recycling, in which plastics are broken down into original raw materials. But reduction takes precedence over recycling.

"The light weighting trend in packaging results in more less recyclable packaging. Those effects are in direct conflict with each other."

Tom Szaky,
CEO at TerraCycle,
United States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A:
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C:
Societal responses
1. Analysis
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B:
Packaging and sustainability
D:
European facts and figures
Central line of argument
Substantiation

Chapter

Packaging and sustainability

B

B.1 Introduction

The application of plastics as a packaging material has increased, without properly addressing the alleged circularity issues and how they are perceived by the media and public. Therefore, in this publication the primary focus of packaging materials will be on plastics. To a large extent, we can use the lessons learned for other materials too.

"We need to design a family of packaging components that reflects the climate emergency we are in without compromising the customer experience. Packaging has to be designed for the whole lifecycle and it must be designed to protect people and planet."

Tracy Sutton,
Founder and Lead Consultant at Root,
The United Kingdom

Public and political debates on packaging emphasises its real and putative impact on the environment, nature and our climate. In recent years, litter, plastic soup and climate change have attracted an impressive amount of attention from the media, politicians, civil society organisations and the public. Fierce debates have raged about plastic carrier bags, shrink-wrapped cucumbers (see Chapter A.6), and disposable plastic products of which the plastic carrier bags have since not been available freely and without an extra charge. Today, all kinds of packaging, particularly those made of plastic, are - even more than ever - in the centre of the public debate.

Various studies have compared packaging made from plastics with alternative materials. One of those studies has been a Life Cycle Analysis (LCA) with complex calculation methods in the USA, as shown in *Figure 18*. In this case, plastics outperform other materials.

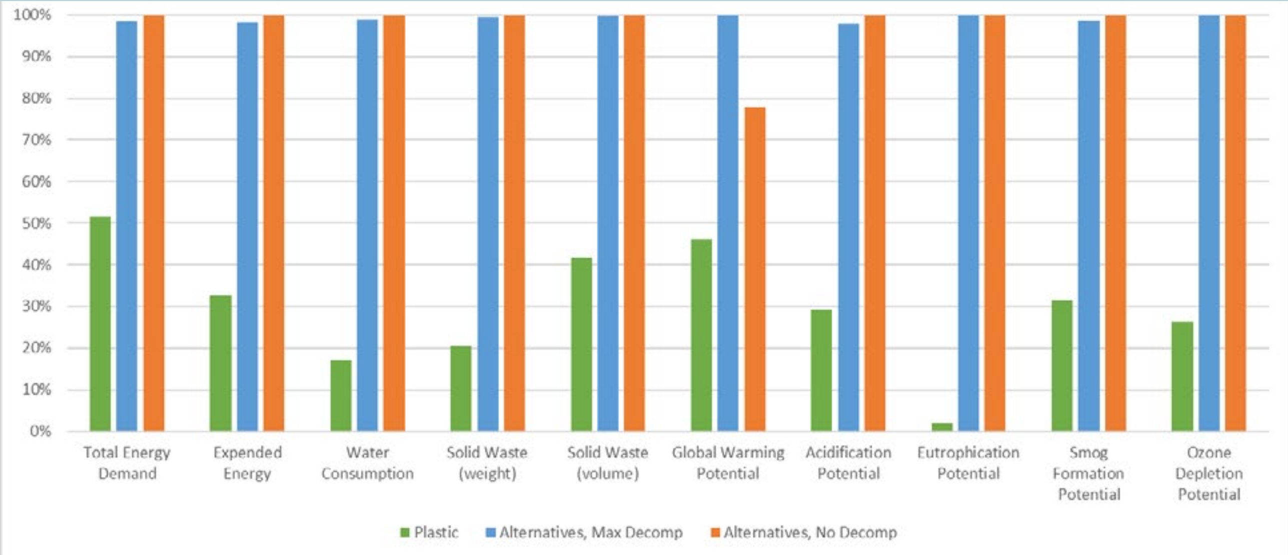


Figure ES–3. Normalized US Results for Plastic Packaging and Substitutes

FIGURE 18 - LCA PLASTIC PACKAGING AND SUBSTITUTES IN THE USA .[38]

It should be noted that the outcomes of such analyses can differ considerably, depending on the aim of the study, the system boundaries/demarcation, the impact parameters used, and the properties and characteristics of the waste sector in the country under study. The notion that plastics are the bad guys and that current alternatives are better is simply not supported by the academic literature, even when a wide range of impact factors are taken into consideration (see Chapter B.2). Add to that the fact that packaging also plays a protective role, which sees packaged products outlive their non-packaged alternatives. One could say plastic is not so bad at all, at least in comparison with contemporary alternatives and in relative terms.

"The choice for the right packaging is made by the triangle marketing-purchase-quality. (...) We base our decision on end-to-end LCA studies. If plastics score the best, also in the field of environmental impact, we choose plastics."

Henk van Harn,
Director Preservable and non-Food at Albert Heijn,
The Netherlands

This chapter will analyse the ecological issues associated with packing and products and their packaging, before zooming in on the debate in society. Both these considerations can be valuable in designing an environmentally friendly packaging strategy compatible with societal and political dynamics and fits in with broader corporate visions of the future.

B.2 Planetary boundaries

Limits to (unsustainable) growth

In 1972, 'Limits to Growth' was published, and this first report published by the Club of Rome caused worldwide upheaval.[39] The report gave rise to a tidal wave of media attention and growing awareness of themes that had remained under the radar until then: depletion of resources and an array of pollution that – if we did not change our ways – could at some point, undermine the economy. This was the moment the impact of production and consumption of goods and services became a prominent issue. It is true that this prominence fluctuates and key issues can change over time, but our awareness of mankind's influence on the planet is here to stay. The large body of research that followed the initial report of the Club of Rome has furthered our knowledge of the environment, bringing us closer to solving many pressing issues. Acid rain, for instance, has been dealt with effectively in the industrialised West, and new economies such as China and India are rapidly becoming aware of the importance of the environment. Ozone depletion has largely been halted because the underlying mechanisms have been unravelled and measures have been taken to reduce the use of substances that lead to ozone depletion, such as the infamous chlorofluorocarbons (CFCs). In the industrialised world, eutrophication, or the excess enrichment of waters with phosphate in particular, has also been greatly reduced.

Environmental impact

In recent years, much research has been done to systematise the main threats faced by humanity, the environment and ecosystems. This research is necessary because the environment is a complex system in which an effect can be caused by several factors. The concept of planetary boundaries is used to distinguish nine key processes and factors that play a major role in regulating the health of the planet *(see Figure 19)*.[40]

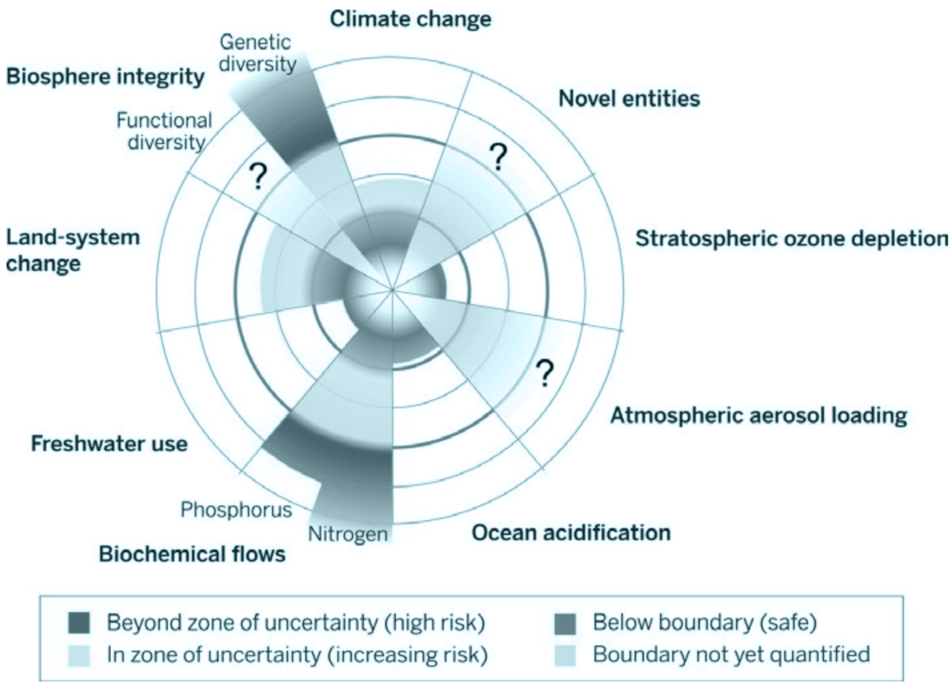


FIGURE 19 - PLANETARY BOUNDARIES: NINE KEY PROCESSES AND FACTORS THAT PLAY A MAJOR ROLE IN REGULATING THE HEALTH OF THE PLANET.

1. Climate change: caused primarily by greenhouse gas emissions and land use.

2. New entities: biological entities, such as invasive species and chemical compounds not found in the environment and which may be toxic to humans, animals or ecosystems.

3. Ozone depletion ('hole in the ozone layer'): the depletion of the ozone layer protecting the earth by reactive chemical compounds.

4. Atmospheric aerosols (small to minuscule particles in higher layers of the atmosphere).

5. Ocean acidification: caused mainly by the greatly increased levels of carbon dioxide (CO2, carbon dioxide) in the atmosphere.

6. Biochemical substances: in particular nitrogen and phosphorus compounds, with direct effects on nature (nitrogen deposition), eutrophication and influence on ozone depletion through nitrous oxide, N2O, among others.

7. Freshwater use and extraction: increasing scarcity of freshwater resources and its impact on biodiversity and local climates, among other things. Freshwater extraction also contributes to rising sea levels through use and evaporation.

8. Changes in land use: which can lead to emissions of greenhouse gases such as CO2 and methane, and have direct effects on biodiversity.

9. Biosphere integrity, in particular, biological diversity (abundance of species, biodiversity): which determines the resilience and productivity of ecosystems, and the ‘services’ that these ecosystems provide to the economy (ecosystem services) such as air, land and water purification, incremental growth of renewable resources. *See Figure 20* about plastics ending up in the soil. The plastic soup can be seen as a violation of the integrity of the (aquatic) biosphere, which affects marine life.

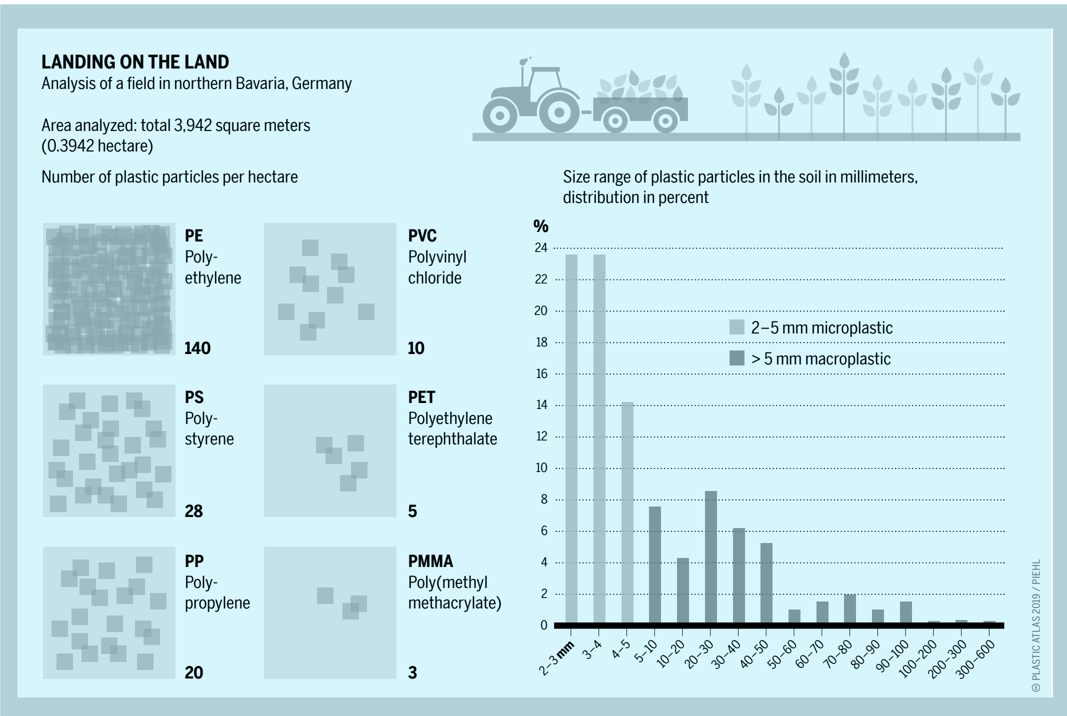


FIGURE 20 - “HOW MANY PLASTICS END UP IN THE SOIL IS LITTLE RESEARCHED. BUT SOIL CONTAMINATION IS THOUGHT TO BE BETWEEN 4 AND 23 TIMES HIGHER THAN IN THE SEA.” [41]

Viewed in this light, climate change and plastic soup are two elements in a broad spectrum of natural and environmental problems that affect the health of people, plants, animals and the earth's ecosystem.

As research advances, the exact categorisation of the nine key processes and factors is subject to discussion. However, many similarities can be drawn between this method and other scientific analyses.[42] In *Figure 20* we introduce the Life Cycle Analysis (LCA): a methodology widely applied to analyse and compare the environmental impact of products and quantify this to financial impact. The 'environmental interventions' or 'impact factors' in the LCA methodology, are comparable with the planetary boundaries.[43]

The relationship with packaging

Packaging, and product-packaging combinations in particular, is linked to many of the planetary boundaries' key processes and factors. The 2030 Sustainable Development Goals (SDG) are also of importance to packaging.[44] Therefore, in this section, we will take a qualitative look at all packaging materials:

1. Climate change: the production and processing of packaging (usually) require the consumption of fossil energy, which, when burned, releases greenhouse gases, particularly CO_2. Plastics are mainly produced from fossil sources; the production of glass and metals is energy-intensive and therefore also carbon-intensive. The same applies to paper and cardboard, though these emissions are offset by growing new raw materials. The use of recycled materials, which can be done at high ratios for glass, paper, cardboard and metals, can significantly reduce carbon-intensity. According to Material Economics, plastic packaging emissions are currently just 1% of EU CO_2 emissions.[45]

"When I post on LinkedIn that all our soups will be packaged in glass, I earn many likes from consumers thinking this is a good move, but our CO2-emmissions will be of the chart."

Robbert de Vreede,
Executive Vice President Global Food at Unilever

2 New biological entities may be indirectly related to packaging: the functionality of packaging enables the transport of (packaged) goods over longer distances and to environments other than the area of origin, where they may be an exotic species. There are also chemical entities: a variety of additives used to ensure packaging meets the right functional specifications. Moreover, the incomplete, uncontrolled combustion of packaging waste can produce toxic substances. This may happen in developing countries, for instance, when chlorine, fluorine or brominated compounds are incinerated without taking adequate measures. The micro- and nanoplastics are a relatively new factor affecting the integrity of the biosphere *(see also Figure 21)*.

3 Ozone depletion: since the Montreal protocol effectively limited the use of ozone-depleting substances, this does not seem to be an important issue for packaging anymore.

4 Atmospheric aerosols may be formed by (incomplete and uncontrolled) combustion, as explained in item 2.

5 Ocean acidification can be linked directly to carbon emissions in the packaging chain, connecting the packaging industry closer to the issue of climate change.

6 Even in bio-based packaging, biochemical substances such as phosphorus and nitrogen compounds are used as fertilisers, which can disturb farming practices. Also, nitrogen compounds can be produced when packaging is burned.

7 The extent of freshwater extraction required for packaging depends strongly on the material and production processes in question. For crops, freshwater extraction can play a role in irrigation. Cleaning waste streams for reuse in the production process may also require the use of freshwater.

8 For packaging from biological sources (plants and trees), land use can be a significant factor. Most of the bio-based plastics are presently produced from starch or sugar. The land needed to grow the feedstock for the currently produced bio-based plastics worldwide amounts about 0.02% of the arable area. If we would base all present worldwide fossil plastics production on biomass as a feedstock instead, the demand for feedstock would be in the order of 5% of the total amount of biomass produced and harvested each year by mankind. But such scenarios may not happen since it is expected that the industry will develop alternative feedstocks from side-streams of the agro-industry, such as beet-pulp.[46]

9 Damage to the integrity of the biosphere can vary greatly in terms of material, location (in which habitat production activities take place) and working method; further analysis per chain is necessary for the bigger picture. Plastic soup can also be seen as a violation of ecosystems, as is the case with micro- and nanoplastics, and additives can cause (ecosystem) toxicity.

This general overview gives a first impression of the processes and factors through which packaging influences the health of our planet. Ultimately, the processes and factors should be explored in more detail through further analysis, distinguishing between materials, the design of the production chains, the state of technology, which can vary considerably from chain to chain, material to material and country to country, and even the specific conditions under which production takes place.

Micro- and nanoplastics

In recent years, increasing attention has been paid to micro- and nanoplastics: small pieces or fibres of plastic which originate from synthetic clothing, cosmetics, toothpaste, car tyres and larger parts of plastics gradually breaking down in smaller and smaller particles, ending up everywhere in our biosphere, our food chains and our bodies. There is growing evidence that micro- and nanoplastics are occurring on an increasingly massive scale in our surface water and air. And even our drinking water is now polluted by nanoplastics. Recently, an amount of about 4.000 parts of microplastics was found in one kilogram of compost.[47] Another study suggests that an average person could be ingesting approximately 5 grams of plastic every week. The equivalent of a credit card's worth of microplastics.[48]

> *"We urgently need to know more about the health impact of microplastics because they are everywhere - including in our drinking water. (..) Based on the limited information we have, microplastics in drinking water don't appear to pose a health risk at current levels. But we need to find out more. We also need to stop the rise in plastic pollution worldwide."*
>
> *Maria Neira,*
> *Director of the Department of Public Health, Environment and Social Determinants of Health at World Health Organization (WHO)*[49]

Micro- and nanoplastics are forcing their way into the human food chain. The dangers these plastics and their additives pose for living organisms, including humans, are still largely uncharted territory, but it will be tricky if we do not start to solve this problem before the biosphere is entirely contaminated. *Figure 21* shows how we are exposed to toxic chemicals and microplastics at all stages in the plastics life cycle.

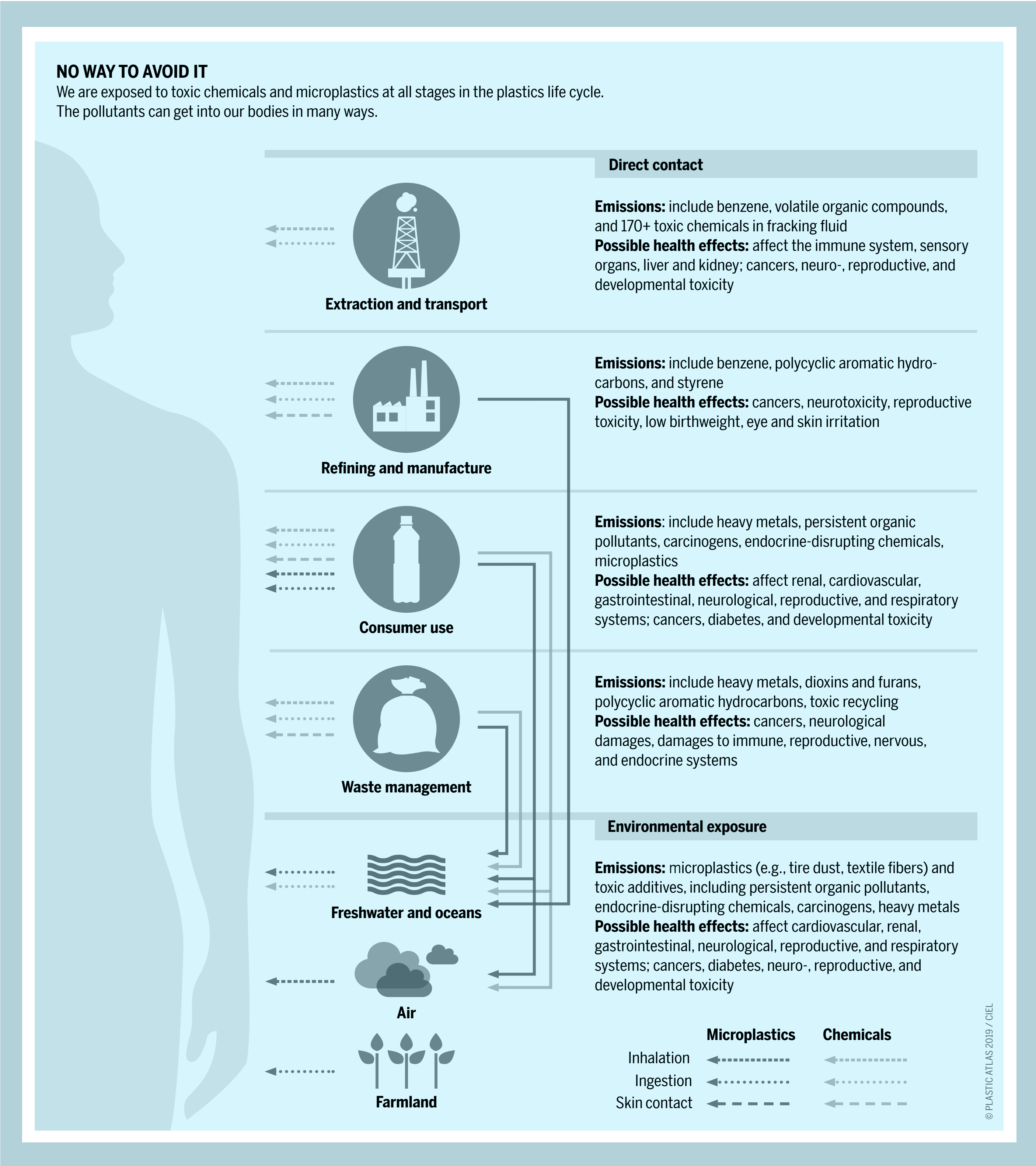


FIGURE 21 - HOW HUMANS ARE EXPOSED TO TOXIC CHEMICALS AND MICROPLASTICS AT ALL STAGES IN THE PLASTICS LIFE CYCLE". 50

Because these interventions in our biosphere are largely irreversible, both the World Wildlife Fund for Nature (WWF) and the World Health Organization (WHO) argue that this pollution must stop.[51] To some extent, this is a precautionary measure, but scientists have now also started issuing warnings[52], prompting governments, the business community, concerned citizens and NGOs to pick up this message.

B.3 Life Cycle Analysis

The Life Cycle Analysis (LCA) methodology was developed for the analysis of environmental impact, forming an instrument to compare the environmental consequences of alternative chains of production and consumption, even if there are major differences between these chains.[53] This supports decision-making and selection, provided it is used prudently. Frequently applied standards and guidelines for LCA's have been set by ISO.[54]

LCA's are instrumental in analysing and subsequently comparing (reasonably) well-known production and consumption processes. They focus on existing or well imaginable chains. This analytic nature makes them suitable for supporting decision-making in the here and now (on the short term). A downside of this may be that exploring quite innovative chains of production and consumption for the future, as is required for intrinsically sustainable development, is given less attention. This type of innovation is design-based, rather than analytical in nature.

Using the LCA methodology to compare different processes and materials is a complex affair, because materials have different functionalities and are not necessarily perfectly interchangeable. Weight-based comparisons between materials, for instance, are relatively pointless for exactly that reason. Packaging costs in Euros for a 'standard' product unit would provide a better basis, leading to metrics such as environmental impact per Euro spent on packaging per (functional) unit, but this approach also has its limitations. The best way to use LCA's in the packaging debate is as a tool to facilitate a design and development process to select the right material and design for a given functionality. In *Figure 22* an example is given for an assessment of different PET bottle packaging systems for milk.

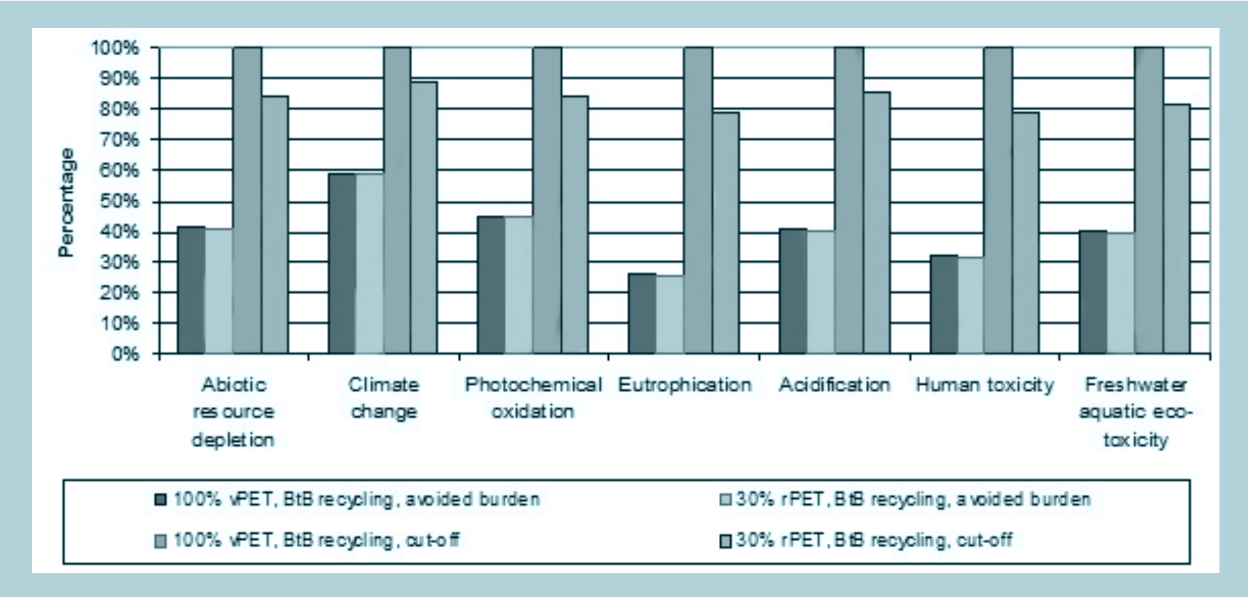


FIGURE 22- AN EXAMPLE OF AN LCA-ASSESSMENT FOR THE ENVIRONMENTAL IMPACT OF DIFFERENT PET BOTTLE PACKAGING SYSTEMS FOR MILK FROM CRADLE TO GRAVE. 55

There are also online tools available to quickly assess recyclability, circularity and environmental impact of different packaging types, as shown in *Box 17*.

Box 17: Sustainable Packaging Compass

With the Sustainable Packaging Compass, KIDV supports producers and importers in their packaging development process, by improving the sustainability of packaging.

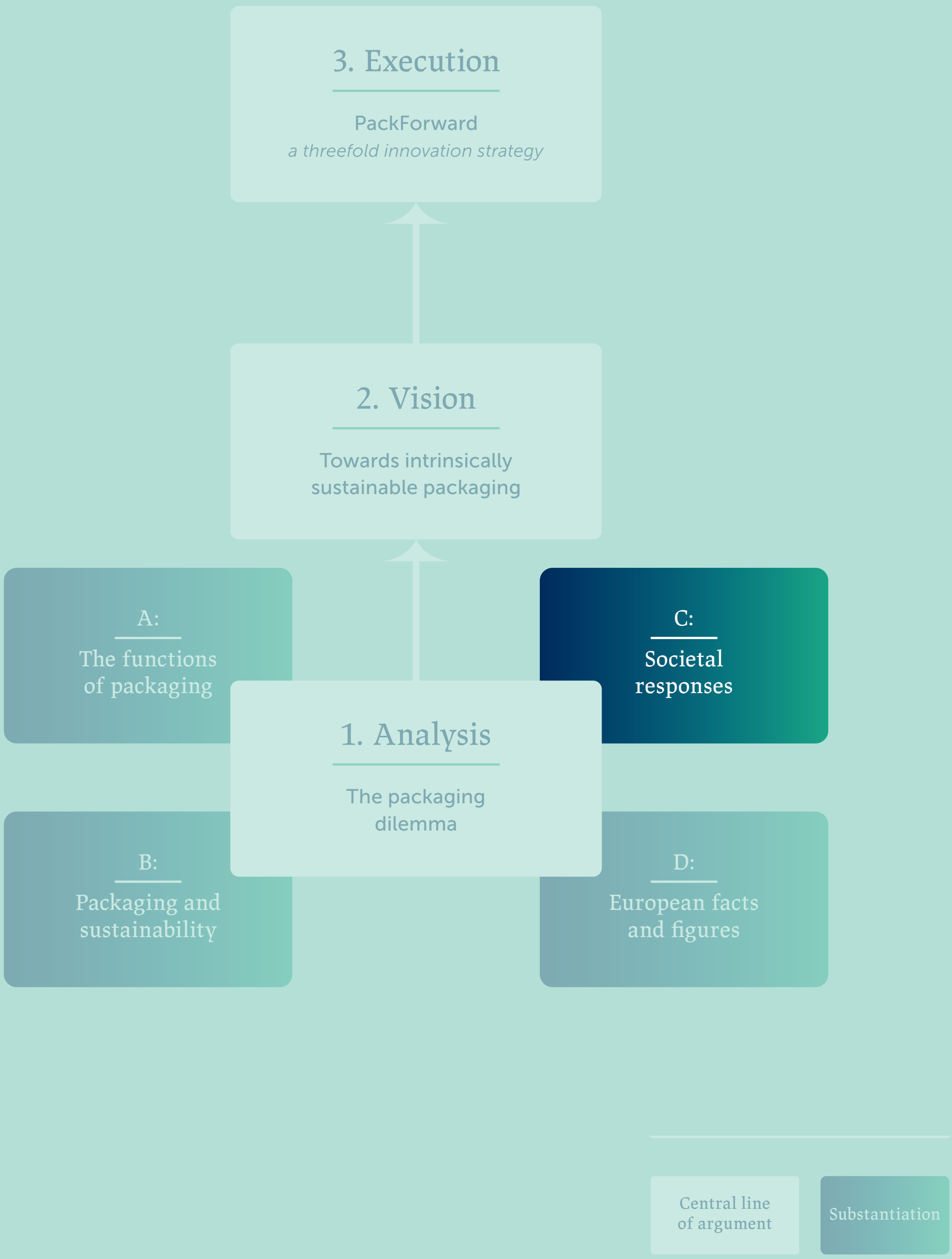
The Compass is based on a four-step evaluation to compare packaging combinations on their sustainability within a user-defined framework. The four-step evaluation contains a recyclability module, a circularity module, an environmental impact module and a comparison module.

Each module can be used by entering specific packaging data. Together, the modules provide a measurement of circularity. The Sustainable Packaging Compass provides valuable information which can be used to improve the sustainability of packaging during the first two of the three innovation tracks: recycling and circularity. This tool is expected to be launched in Autumn 2020.

A drawback of comparing various types of packaging with an LCA assessment is that it provides no insight about the differences in quality and life span of the product for which it was created. These consequences can easily overshadow the environmental impact of the packaging and often do so as well. After all, packaging typically makes up a minor part of the packaging-product combination, both in terms of weight and costs, which are often commensurate to environmental impact. On the other hand, the environemental losses caused by products with a dysfunctional packaging or no packaging at all, such as damaged or rejected goods, shortened life span, spoilage, waste and the like, can be very heavy indeed. This consideration should always be taken into account in any debate on the environmental impact of packaging.

LCA's that incorporate the effects of packaging on the packaged products do exist, and more and more people are starting to ask whether food-related LCA's should not take packaging into account.[56] This seems a rhetorical question.

Another drawback of LCA methods is that they do not consider the damage that products cause when they end up in the environment. According to the Plastic Soup Foundation, a legitimate supplementary criterion that considers the impact plastic has once it inevitably reaches the environment should be agreed upon.[57] According to Insitute for European Environmental Policy (IEEP), there is too much focus on carbon emissions and too little on end-of-life impacts.[58] However, simply replacing plastics by another material, will lead to similar problems. For example, we are not able to quantify how much mineral oils from recycled paper and cardboard will be leaching.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Chapter

C

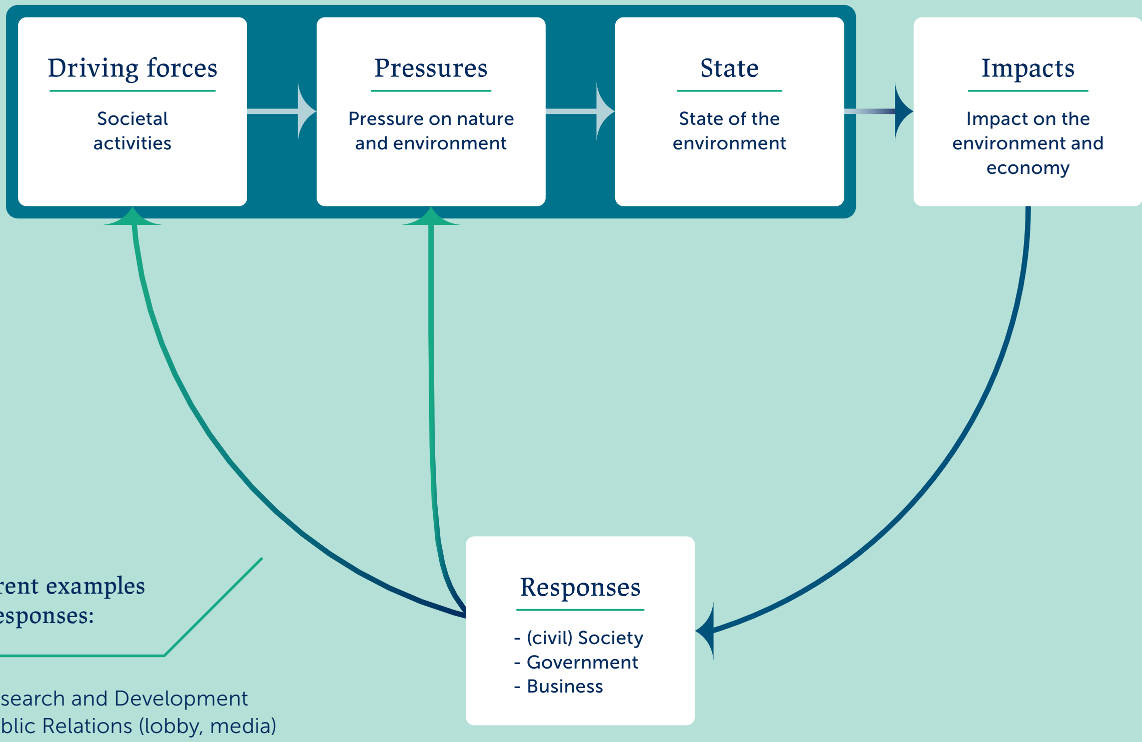
Societal responses

C.1 Introduction

For years, packaging methods and materials have been the topic of a broad social discussion. Packaging waste affects us all. Daily, people are confronted with litter in their direct environment and growing media coverage of plastic soup and other environmental pollution. This has resulted in a significantly stronger societal response, particularly the past two to three years. This chapter presents an overview of the various responses to the environmental effects that are or can be caused by, in particular, plastic. These responses are described using the DPSIR model *(see also Figure 23)*, which consists of:

- **Drivers**: the driving forces and developments, such as increasing prosperity, the desire for multiple options, trends towards greater (food) safety and more.
- **Pressures:** the impact factors that ultimately lead to negative effects, such as carbon emissions, which increase greenhouse gas levels in the atmosphere, changing the earth's energy balance and thus causing global warming. Other pressures include water extraction, discharge of toxic substances, plastic soup and so on.
- **State:** the state or quality of the environment or nature. This can be anything from greenhouse gas levels in the atmosphere to groundwater levels or the amount of plastics in a certain part of ocean.
- **Impacts:** the ultimate consequences of a change in the environment or in nature, such as global warming due to the higher concentration of greenhouse gases and all subsequent effects such as rising sea levels, extreme weather and the like. An example is an increase in the human death rate due to pollution.
- **Response:** the reactions of society and policymakers, primarily addressing the Impacts, but reactions may also point towards earlier parts of the causal chain.

The original model rapidly became more popular in the 1970s, when Response was still exclusively the purview of government, who were still "in command and control". Today's responses are not limited to governments, since business communities, civilians, NGO's and scientific institutes are also responding to the impact of packaging waste. Civil society is stirring, with groups of people attempting to force change because they fear that something is going or is about to go wrong. The media also plays a role in this civil society improvement cycle, either by directly targeting the producers who use certain packaging or by trying to influence those who are in any other way responsible for the problems according to civil society, like governments. The media can try to influence policy or try to pressure the government into taking more measures and/or change their approach. The next paragraphs will give an overview of different societal and political responses to packaging waste.



Current examples of responses:

- Research and Development
- Public Relations (lobby, media)
- Extended Producer Responsibility
- Commitment to goals (pledges)
- Policy and legislation
- Court ruling

FIGURE 23 - DPSIR MODEL, ADAPTED FROM PBL.[59]

C.2 Societal responses

Societal concerns about the use and disposal of plastic packaging are a relatively new phenomenon, revolving mainly around microplastics, plastic soup polluting the oceans and today's linear model of the production and consumption of plastic packaging.

Some examples of societal responses:

- In 1997, Charles Moore discovered the Great Pacific Garbage Patch, which has since been the subject of various documentaries and books, showing images of sea creatures entangled in plastic and plastic 'islands' floating in the ocean. Notable examples are 'Plastic Ocean' (2016) with Craig Leeson and 'Blue Planet II' by the BBC with David Attenborough (2017).[60]
- Various organisations are committed to fighting the pervasive presence of plastics in the environment, with organisations such as Greenpeace, The Plastic Soup Foundation, and the World Wildlife Fund for Nature setting up campaigns, organising activities and providing education to reduce plastic pollution in the ocean. The Ocean Cleanup is developing a technological solution to clean up plastics found in oceans and rivers.
- More and more consumers now demand that the business community takes a critical look at packaging, plastics and otherwise. Organisations like A Plastic Planet[61] call for the complete elimination of plastics.
- All around the world, people are organising so-called Plastic Attacks[62], in which consumers leave plastic packaging behind in supermarkets.
- In recent years there have been major joint clean-up operations, such as World Clean-up Day in 2018, with 18 million participants putting in an effort to clean up the environment from plastic.
- In 2017, the Ellen MacArthur Foundation published a report titled 'The New Plastics Economy', setting out specific courses of action:
  - Eliminate: eliminating all problematic and unnecessary plastic products.
  - Innovate: innovation to ensure that all plastics we use are suitable for reuse, recycling or composting.
  - Circulate: ensure that all plastic products and packaging remain in the economy, so that they do not end up in the environment.

These types of responses force producers and importers of packaged goods to make a change, and if sustainable solutions will not be made, this social pressure will only increase. Companies experience that sustainable packaging is a serious part of their licence to operate.

C.3 Political responses (EU)

In response to the mounting social pressure, governments are introducing initiatives designed to reduce the pollution of the natural environment, increase recycling percentages and to stimulate the circular economy. The European Commission is an important player in this.

The European Union has responded with different types of legislation. For example, by implementing targets on recycling rates and Extended Producer Responsibility. The most responsive countries supported waste-to-energy and/or recycling. About half of the European countries haven't responded adequately, as illustrated in *Figure 24*.

FIGURE 24 - HALF OF THE EUROPEAN COUNTRIES ARE AT RISK OF MISSING THE MUNICIPAL WASTE RECYCLING TARGET OF 50% BY 2020. [63]

"Most of the strategies targets and policies from governments encourage disposability and consumption. They mainly focus on recycling and adding recycled content to single use packaging. They focus on making waste simpler and easier to collect. This approach forces us to make single use a bit better – it's a broke system that needs to be redesigned. We need to set out clear, bold strategies that inspire and incentivise using less resources in the first place."

Tracy Sutton,
Founder and Lead Consultant at Root,
The United Kingdom

The European Union currently employs an increasingly comprehensive set of regulations, Green Deal and voluntary agreements. The most relevant ones are introduced here.

Recently, the European Commission has launched the EU Green Deal for the European Union and its citizens.[64] It resets "the Commission's commitment to tackling climate and environmental-related challenges that is this generation's defining task." The EU Green Deal is a policy document and time frame of key policies and measures. Relevant for the packaging issue is the inclusion of sustainable products policies to support circular design, transition of resource-intensive sectors such as plastics and measures to encourage business products which are reusable, durable and repairable. In 2030, all packaging put on the market should be reusable or recyclable. According to the European Commission, a sustainable product policy has the potential to reduce waste significantly. Regarding packaging, the Green Deal builds upon policy of the previous European Commission.

The Climate and Energy Package contains of binding legislation which aims to ensure the European Union meets its ambitious climate and energy targets for 2020. These targets, known as the "20-20-20" targets, set three key objectives for 2020: A 20% reduction in EU greenhouse gas emissions from 1990 levels; Raising the share of EU energy consumption produced from renewable resources to 20%; A 20% improvement in the EU's energy efficiency.[65] For 2030, the targets are "40-32-32,5". Sustainable packaging can play a role as enabler to prevent waste.

Next, we will give an overview of the European Union's foremost Directives and Strategies about packaging *(see also Figure 25)*.

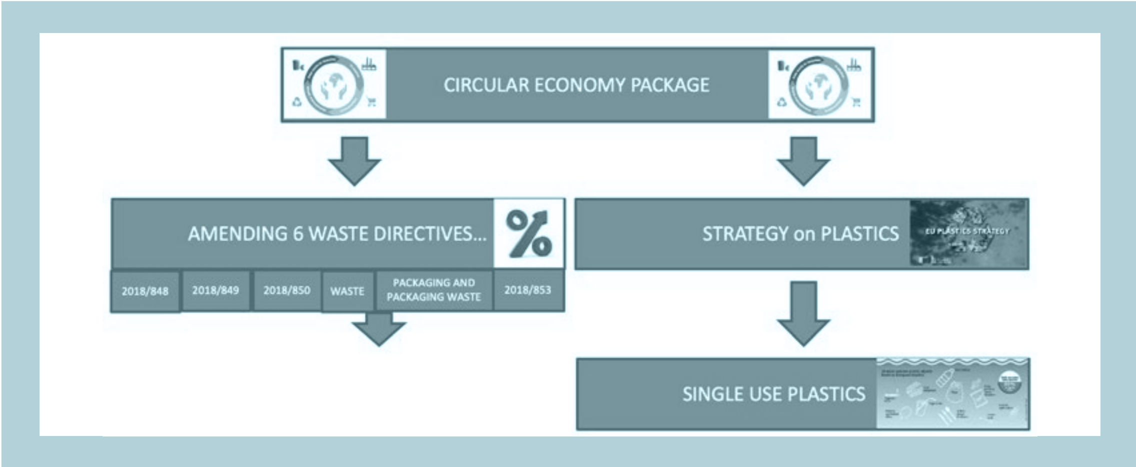


FIGURE 25 - EUROPEAN UNION'S FOREMOST DIRECTIVES AND STRATEGIES ABOUT PACKAGING.

As part of the Circular Economy Package, the previous European Commission adopted an Action Plan for the Circular Economy in 2015.[66] This plan presents measures throughout the chain, ranging from production to recycling, in five high-priority sectors: food waste; plastics; critical raw materials; construction and demolition waste and biomass and bio-based products. Regarding food waste, the European Commission has committed itself to the United Nations Sustainable Development Goal to halve food waste at retail and consumer levels by 2030.[67]

The EU Strategy for Plastics in the Circular Economy and annex aims to change the way plastics and plastic products are designed, produced, used and recycled. Its main objectives are:

- All packaging must be reusable or recyclable by 2030.
- The sorting and recycling capacity of the EU must quadruple by 2030 compared to 2015.
- Marine litter must be monitored and reduced.

The EU Single-Use Plastics Directive seeks to reduce marine litter. Its main objectives are:

- To prohibit disposable plastic products for which there is a reusable alternative, such as plates, cutlery and cotton buds.
- PET bottles should contain at least 30% recyclates by 2030.
- 90% of bottles should be collected separately for recycling by 2029.
- Starting 2021, Extended Producer Responsibility will apply to most food packaging, with producers having to pay for the costs of collecting and recycling plastics. Public awareness campaigns will be launched.

The Waste Framework Directive[68] sets clear targets for waste reduction, waste management and recycling. By 2035, 65% of household waste must be recycled, while 70% of packaging waste should be recycled by 2030. The Directive on Packaging and Packaging Waste[69] sets specific recycling targets for 2030 for certain packaging materials: Paper and cardboard 85%, metal 80%, aluminium 60%, glass 75%, plastics 55% and wood 30%.

"For packaging we created independent regulations. The EU Packaging and Packaging Waste Directive is scheduled to be renewed this year. Hereto design for recycling is crucial, although we are in an everlasting battle with rules for food safety. These rules hinder us to recycle packaging for food applications in the next cycle."

Diederik Samsom,
Head of Cabinet of Executive Vice-President Frans Timmermans at the European Commission

Extended Producer Responsibility (EPR) is a system in which producers are financially held responsible for the environmental impact of the product they sell over the course of its lifetime. The Waste Framework Directive provides whether the producer of a product "has extended producer responsibility". The implementation of EPR is organised by the Directive on packaging and packaging waste. Producer responsibility applies to a wide range of producers, such as for packaging, electronics and cars, and should cover the costs of waste collection, recycling and processing.

European countries regulate producer responsibility in the field of packaging in two ways:

1. Applying a waste management fee paid by producers and importers per unit of packaging or quantity of packaging material put on the market, which is used to pay for the collection and recycling processes. Because the fee is linked to weight and recyclability, producers are encouraged to develop more recyclable packaging.

2. Applying deposit systems, in which customers return packaging for reuse or recycling. This deposit is a small amount paid on purchase and refunded upon return, to encourage consumers to not dispose of but rather save the packaging and return it.

Different EPR-schemes for packaging have been introduced in the EU member states. Some examples of these different approaches are:

- The Netherlands and Germany have introduced wide-ranging collection systems for plastic packaging, whereas collection in France is selective.
- Unlike other countries, Belgium and Austria have separate systems for consumer packaging and industrial packaging.

- EPR systems in Denmark and Hungary are controlled by the government, whereas Germany works with several competing private companies.
- In the Czech Republic, the collection of plastic packaging and other plastics is combined.
- The Netherlands, Spain and Norway have post-collection waste separation systems.
- Different countries use different technologies. In Greece and the Czech Republic, plastic packaging waste is sorted by hand-pickers, whereas the vast majority of waste in Western Europe is sorted mechanically.

As a result of these different approaches, also the EPR performance on the collection and recycling of plastic packaging waste varies between the different EU countries. *Table 3* contains an overview of selected EU countries:

	Recycle targets 2015	**Realisation** System municipal plastic packaging waste (MPW)	**Realisation** MPW and plastic packaging waste for businesses together
Belgium	30% Domestic	29% (2015)	41.3% (2015)
France	Overall objective of 75% domestic	22.5% (2014)	25.2% (2014)
Germany	36%* Domestic	28.4% *** (2015)	48.8% (2015)
The Netherlands	45% Domestic & Businesses	38% (estimate 2015)	51% (2015)
Czech Republic	40%* Domestic & Businesses	Not available	66%** (2015)
Greece	22.5% Domestic & Businesses	Not available	35.2% (2015)

*The Czech Republic's 40% target is a collection target at the sorter's front gate rather than, like the other countries, a target that is measured after sorting, at the recycler's front gate. The 36% recycling target for Germany refers to the amount licensed.
** The percentage realised in the Czech Republic refers to collection because this country has set a collection target rather than a recycling target.
*** This percentage does not include the deposit-refund flow and refers to the total amount of domestic plastic packaging waste onto the market and not to the amount licensed.

TABLE 3- DIFFERENCES IN EPR PERFORMANCE BETWEEN EU COUNTRIES.[70]

C.4 Responses from business circles

More and more companies are taking responsibility for tackling problems caused by plastic packaging and products. Through the Circular Plastic Alliance, the European Commission encourages voluntary agreements by industry parties to supply and use recycled plastics in new products. The target is to use 10 million tonnes of plastic recyclates by 2025.[71]

In The New Plastics Economy, international companies, businesses and other organisations have set a shared vision and goals in 2018 to combat plastic pollution at the source. The Ellen MacArthur Foundation works with UN Environment and its affiliated companies and retailers, such as Carrefour, Colgate Palmolive, Danone, L'Oréal, MARS, Incorporated, Nestlé, SC Johnson, The Coca-Cola Company, and Unilever, which together are responsible for over 20% of all plastic packaging on the global market today.[72]

In addition, Plastic Pacts have been adopted in several EU countries, which involve network initiatives voluntarily committing to a clear vision and set of objectives. In the United Kingdom, the UK Plastics Pact was concluded with the support of WRAP (Waste and Resources Action Programme), France has seen the introduction of the Pacte National sur les emballages plastiques and the Plastic Pact NL was set up in the Netherlands.

In March 2020, the European Plastic Pact was launched in Brussels, supported initially by more than 80 organisations from across Europe. The objectives are:

- Use 20% less virgin plastics with 10% absolute reduction.
- Use at least 30% of recycled plastics in new plastic products.
- Design 100% recyclable and reusable products where possible.
- Increasing recycling rate by 25%.[73]

C.5 Knowledge activities in Europe

Besides societal and political responses knowledge development plays and important role in improving sustainable packaging. Knowledge about sustainable packaging is being gained by companies, knowledge institutes and network initiatives, leading to new developments. It goes beyond the scope of this publication to present a detailed overview of the work being done by all universities, universities of applied sciences, other institutions and consultancy firms. However, to give an impression of the field, *Box 19* explores a few examples in greater detail.

Box 18: Examples of knowledge development

Many of the larger producers and importers have their own department that researches packaging materials. Some organisations have ramped up their efforts in regards to research into packaging materials. Unilever, for example, opened a new R&D centre in 2019 that partly devotes its attention to the development of sustainable packaging materials[74], Friesland Campina has an R&D centre in Wageningen, the Netherlands and Nestlé recently launched its own research institution.[75]

Furthermore, there are several research institutes that support businesses (and other clients) with research into packaging methods and materials. Some of the renowned organisations that also focuses on packaging materials are Fraunhofer IVV[76], WRAP and Pack4Food.

Lastly, there are various universities that research certain specific areas of the field of (sustainable) packaging. Karlstad University (Sweden) for example, is researching the role of packaging materials and ways to prevent food waste, Vienna University (Austria) combines packaging technology and sustainability and Delft University of Technology (the Netherlands) is researching various sorting techniques. Linköping University (Sweden) explores questions related to packaging design and display, Lund University (Sweden) specialises in packaging and logistics and Ghent University (Belgium) focuses its efforts on food packaging.

A list of some knowledge institutions categorised per topic and country has been published online.[77]

There are international cooperative alliances that focus on exchanging knowledge with regard to packaging. International Association of Packaging Research Institutes (IAPRI) is an international membership association to promote packaging research and education. One of the topics it deals with is sustainable packaging. On their website there is a general overview of developed (scientific) knowledge with regard to packaging available.[78]

Furthermore, there are a number of platforms in Europe that focus on knowledge and/or lobby regarding a specific topic, such as CEFLEX (flexible plastics) and Plastic Recyclers Europe (plastic recycling). Through its ongoing Horizon 2020 programme, the European Union supports various research projects aimed at sustainable packaging, like:

- Mypack, which aims to provide general guidelines to select the best market for a new sustainable technology and to ensure the best commercial development, through the best environmental efficiency (direct impacts of packaging, food waste impacts,

optimised recycling composting combusting end life, preserved consumer health), the best consumer acceptability, and an optimised industrial feasibility.
- The GLOPACK (Granting society with LOw environmental impact innovative PACKaging) project, which is investigating food packaging with no environmental footprint and the ability to extend the shelf life of food products.[79]
- The CIRC-PACK project, which will produce breakthrough biodegradable plastics using alternative bio-based raw materials, which will have an important role to play throughout the plastic value chain.[80]
- MANDALA, which is looking to develop a sustainable packaging format that will, in addition to satisfying business needs thanks to its barrier properties, facilitate recycling. As it will be possible to separate the multiple layers through the development of a thermo-reversible adhesive.[81]
- Horizon Europe, the successor of Horizon 2020, will run from 2021 till 2027 and is expected to have a larger budget.

Circular Economy is likely to remain a key theme and various countries have funded national research programmes. In Germany, most of these programmes are demonstration projects that make products from recycled plastics. In Denmark, there are many feasibility studies, in addition to research into new markets for recyclates. The United Kingdom has announced the Plastics Research & Innovation Fund (PRIF), a fund with a 20-million-pound endowment to set up a network for research and knowledge exchange.

C.6 The need to share and coordinate knowledge

In Europe, the rate at which the packaging chain and waste processing methods are being made more sustainable varies greatly. This is evident when looking at the way in which waste is processed: in the east and south of Europe and in the UK, landfills are more common than in other parts of Europe. The question is whether countries with many landfills have to go through the same knowledge development as the Western European countries with a relatively high recycle rate or if they can proceed immediately with the implementation of much better solutions. It is therefore high time that the innovation tracks of Chapter 3 are widely adopted - both substantively and in terms of scope - and for the sharing of knowledge to be organised in an intensive and Europe-wide manner.

It is striking and therefore must be noted that, contrary to the international lobby, international collaboration and knowledge sharing are happening on an incidental base. The initiatives that are set up internationally only target a specific topic or have a too general approach. The decentralised approach not only creates scattered knowledge but also only provides partly solutions instead of being able to come with a comprehensive approach and solution.

In other words, there is a need for a platform where sustainable packaging is brought together on an international scale, i.e. where the knowledge response is at least shared and perhaps, in time, coordinated. Together with other international parties, the KIDV has taken the initiative to develop such a platform: PackForward.[82] The aim of PackForward is to become the European network and knowledge base for sustainable packaging and to help the different stakeholders in the packaging chain move forward with sustainable packaging. The website www.packforward.eu gives an overview of important themes that affect the sustainability of packaging: from the production process and use of product-packaging combinations up to the stage of waste.

C.7 Societal responses in the Netherlands

There are more and more organisations in the Netherlands working on the reduction of plastic packaging. The Plastic Soup Foundation focuses mainly on plastic in the oceans, microplastics and the health effects of plastic waste. Their activities include campaigns, events and education.

A JOINT PLASTIC FREE RETAIL CAMPAIGN BY A PLASTIC PLANET, PLASTIC SOUP FOUNDATION AND EKOPLAZA

Stichting Natuur & Milieu (Dutch nature and environment foundation) works with the business community, people and the government in the Netherlands to conduct research and lobby for stricter government policy on packaging. Recycling Netwerk is an environmental organisation that focuses on themes such as plastic, litter and bottle deposits. Milieu Centraal (Environmental Central) focuses primarily on informing consumers. NederlandSchoon (the Netherlands clean) is a foundation funded by businesses and the Dutch government that aims to reduce litter.

C.8 Laws, legislation and policies in the Netherlands

Towards a circular economy

In 2016, the Dutch National Governement presented their commitment to a transition towards a circular economy with a 'Progamme Netherlands Circular in 2050'. Subsequently, the ambition of a fully circular economy in 2050 was endorsed more broadly in 2017 in the 'Resource Agreement' by companies, unions, governments, nature and environmental organisations, knowledge institutes, financial institutions and many other social organisations. The 'Resource Agreement' contains agreements to have the Dutch economy run entirely on reusable raw materials by 2050. Currently, more than 400 stakeholders have signed the Agreement.

The 'Progamme Netherlands Circular in 2050' and the 'Resource Agreement' have been elaborated into five "Transition agendas' for Biomass & Food, Plastics, Manufacturing Industry, Circular Building Economy and Consumer Goods.[83]

General Waste Framework

The purpose of the Environmental Protection Act is to protect the environment, providing the government with frameworks for defining and implementing environmental policy. Chapter 10 of the Environmental Protection Act discusses waste. The National Waste Management Plan is the Dutch policy framework for waste in circular economy. All public authorities are obliged to comply with this act when carrying out waste-related activities.

Packaging

The Packaging, Paper and Cardboard Management Decree has been in effect in the Netherlands since January 2006. Under this decree, producers and importers are responsible for the prevention, collection and recycling of the packaging they introduce to the market. The Decree also defines the obligations of the companies to which it applies, as well as laying down essential requirements for sustainable development and increasing the minimum percentages for the reuse of packaging materials in the Netherlands.[84]

In order to achieve the objectives, set out in the Decree, the Dutch government has also defined an approach, as is laid down in the Packaging Framework Agreement 2013-2022. This Framework Agreement provides guidelines for municipalities, the packaging industry and the Government, each of which are responsible for complying with these guidelines. This framework has been updated in 2020 and provides future perspectives towards 2029.[85]

Due to recent changes in waste directives, specifically for packaging and packaging waste, several important changes will come into effect as of 5 July 2020.[86]

- Extended Producer Responsibility: The Waste Framework Directive (2008/98/EG) states that producers must take financial and organisational responsibility for the prevention, collection and reuse of the packaging materials they use.
- Higher recycling targets *(see Table 4)*. The target for glass is currently not being met. The weight and quality of plastic packaging waste submitted for recycling must also be improved.

Material	**% NL 2018 achieved**	**% NL 2018 target**	**% EU 2025 target**	**% EU 2030 target**
All packaging	79%	70%	65%	70%
Plastic	52%	48%	50% (+70%)	55%
Wood	77%	37%	25%	30%
Metal	95%	85%	70%	80%
Aluminium			50%	60%
Glass	86%	90%	70%	75%
Paper and cardboard	88%	75%	75%	85%

TABLE 4 - DUTCH AND EUROPEAN TARGETS AND ACTUAL RECYCLING PERCENTAGE PER MATERIAL IN THE NETHERLANDS

- A new measuring point (recycling versus sorting): Up to now the amount of packaging recycled would be determined by weighing the amount of material accepted by the recycler, but in the new situation the recyclable material (for most materials) will be

weighed at the moment it enters the last phase of the recycling process. This shift of measuring point has a major effect on the absolute amount (tonnes) of plastics to be recycled. The target of 50% plastic reduction by 2025, would have meant a 70% reduction if the old way of measuring would be used.
- Essential requirements are revised to ensure that the clauses are applied more explicitly in practice.
- The EU countries must ensure that the so-called waste hierarchy is implemented, ranging from prevention to incineration and landfill. Fee modulation is one of the instruments that can be used to encourage recycling, by reducing the waste management fee charged for highly recyclable plastic packaging that retains some value when sold to recyclers.

C.9 Extended Producer Responsibility in the Netherlands

In the Netherlands, producer responsibility for packaging is regulated by the Packaging Waste Fund, which fulfils the collective obligations of the packaging industry under the Packaging Management Decree. Its main objective is to implement the Framework Agreement.[87]

The Packaging Waste Fund is financed by the waste management fees paid by the packaging industry, with producers and importers introducing more than 50,000 kg of packaging to the market a year having to pay a rate based on the type of packaging material used.

This waste management fee is used to pay for the activities of the Packaging Waste Fund, which consists mainly of:
- designing and maintaining a waste management structure.
- levying the waste management fee.
- issuing reports on all packaging introduced to the market and the recycling ratios.
- reimbursing municipalities for collecting and separating packaging waste.
- encouraging activities and campaigns to prevent packaging litter.
- steering the material supply chain towards the circular economy.

The waste management fee is also used to support organisations such as:
- Nedvang.
- Nederland Schoon.
- Verpakkingsketen BV (VPKT).
- The Netherlands Institute for Sustainable Packaging (KIDV).

The relationships between these organisations is shown in *Figure 26*.

The waste management fee currently covers the waste processing deficit. What is needed is a process that automatically creates a back-end market, which requires improved sorting and recycling of plastic packaging in the short term.

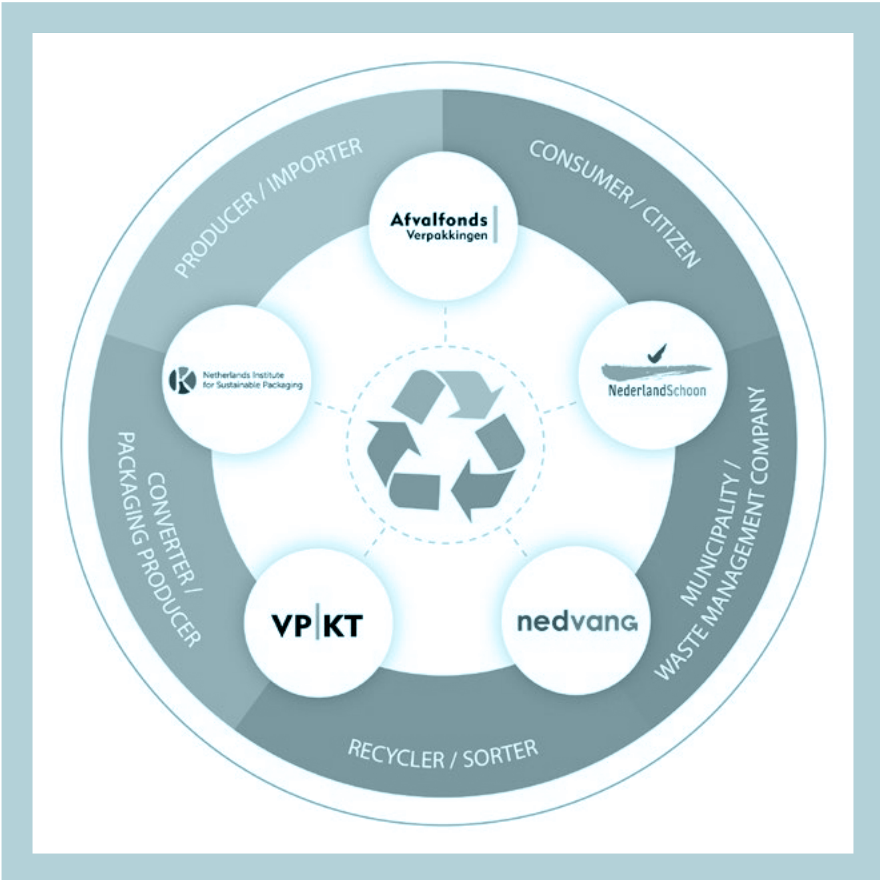


FIGURE 26 - THE WASTE FUND AND THE ORGANISATIONS INVOLVED IN THE NETHERLANDS.

Additionally, twenty two Dutch sector organisations have drawn up a sector innovation plan for Sustainable Packaging 2019-2022.[88]

C.10 Knowledge activities in the Netherlands

In the past decade, the knowledge development and the resulting knowledge infrastructure in the Netherlands has grown significantly. It goes beyond the scope of this publication to present a detailed overview of the work being done by all Dutch universities, universities of applied sciences, other institutions and consultancy firms.

crisp

The Center for Research in Sustainable Packaging (CRISP) is a Dutch cooperative alliance between the KIDV, the University of Twente, Utrecht University and Wageningen Food & Biobased Research. The purpose of this partnership is to help businesses expand their knowledge of sustainable packaging, with a focus on designing packaging materials in a circular manner. The initial projects are centred around laminates, reusable packaging materials and the process of embedding sustainable packaging practices in the organisations' management.

A recent initiative is the foundation of the National Test Centre Circular Plastics (NTCP), where special practical experiments in the field of sorting and cleansing plastic waste streams can be conducted. The NTCP was established with support from the Dutch national government, the provincial government of Friesland and the Packaging Waste Fund.

In 2019, the KIDV completed a Scientific Research Programme named "Design for Circularity." The key findings of this programme are briefly summarised in *Box 19*.

Another leading Dutch institute with a large knowledge base on sustainable packaging, is the Netherlands Organisation for applied scientific research (TNO). TNO has conducted various sustainability assessment studies for the chemical sector, such as an LCA on Environmental Impact of Packaging Policies (as part of the 'Design for Circularity' scientifical research programme). At Brightlands Materials Center, a joined initiative of TNO and the Province of Limburg, they develop new packaging which is more recyclable. TNO also develops technologies for chemical and thermochemical recycling of plastics.

Box 19: "General findings of the scientific research programme "Design for Circularity" 2015-2019 [89]

There are no simple answers to complex issues.

This is certainly true when it comes to the sustainability of packaging materials. It is influenced by all phases of the packaging chain, especially in relation to each other. Decisions made at one point in the chain affect decisions and possibilities throughout the entire chain. As a result, the focus lies often on resolving dilemmas and striking the right balance between different aspects. This requires an interdisciplinary approach to both research and practical implementation, which is no easy feat. Learning to speak each other's language and transferring this knowledge to a level that all parties can manage takes time, motivation and openness.

"It's more important to make the right decisions, even if you get more criticism, instead of taking popular measures which won't make any difference in the end."

Robbert de Vreede,
Executive Vice President Global Food at Unilever

Knowledge is distributed and collaboration is needed.

In the Netherlands, the knowledge in regards to sustainable packaging is divided between knowledge institutions and businesses. Interaction must therefore be organised, which calls for direction on a need-to-know basis. Collaboration between businesses and knowledge institutions is necessary but can (and should) be inspirational. It does bring certain potentially conflicting dependencies to light, between openness and togetherness on the one hand and property rights and framing in the public discourse on the other. Precompetitive research is not that easy to define or implement. With the help of the chain models for plastic packaging materials and the municipal collection efforts, this programme shows just how long the road to a circular economy still is and that the path towards intrinsically sustainable packaging has hardly been explored at all. Change will require a major effort of all parties involved, which can only be realised if we have a thorough and widely supported understanding of what circularity and intrinsic sustainability mean and how we compare our performance to these aspects.

Packaging in the design phase.

How can we make sure that the development teams working on product-packaging combinations think about the entire life cycle of the packaging and take this into consideration during the design phase? Research conducted by the Dutch University of Twente illustrates that this is not yet standard practise and that it is best to explicitly appoint someone to the role of Sustainability Guardian. The research of the Dutch University of Groningen shows that you can also use a packaging's design to give people a nudge in the right direction during the disposal phase - particularly the large group of people with strong biospheric values. Lastly, the research conducted by the Dutch Wageningen University & Research shows the importance of clearly explaining to consumers what they should do. They have limited knowledge of the actual sustainability of packaging materials. Although consumers are willing to purchase sustainable products, they do not always know how to do so. They are wary of possible greenwashing and exaggeration in businesses' communication. Once packaging materials have been disposed of, it is a considerable challenge to make sure they end up in the collection and recycling cycle again. The goal here is twofold: as much as possible and as pure as possible. The research shows that the purity of the recovered material is the decisive factor when it comes to realising a circular economy for packaging materials. A focus on the quantity of material being collected does not necessarily contribute to the purity of the recovered material. The realised purity in the plastic chain often still falls below the standard for high-grade reuse, which also means pollution of the chain itself.

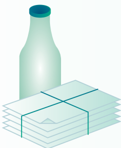
New systems lead to new questions.

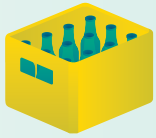
Reduction at the source and high-grade reuse via recycling are core challenges in the circular economy. At the same time, distribution models are changing due to the rising popularity of online business, which leads to a significant increase in the amount of packaging materials being used. Secondary packaging materials are crucial from a communication perspective, as they turn the delivered product into a kind of gift. At the same time, this leads to a lot of additional packaging material - some of which can be reused but all of which will ultimately be disposed of. The challenge herein is to find the right balance between the packaging's communication function, its protective function and its degree of sustainability, as shown by the e-commerce study.

Keep it clean!

In addition to the many possibilities it offers, high-grade reuse via recycling also has some clear limitations, as shown by the study of rPET and WPC (waste paper and cardboard). With repeated reuse, the purity of the recycled material goes down, which may ultimately affect the functionality and applicability of the packaging materials based on these recycled inputs. Although there are ways to remove such impurities, these must be developed further before they can be utilised on a large scale.

Timeline





1960 1965 1970 1975 1980 1985 1990

1960-1970 Start of collecting waste paper and used glass bottles (NL). The main reasons are economically driven. The fast growth of economy causes issues.

1972 Report by the Club of Rome: Limits to growth by Meadows et al.

1976 The concept of cradle to cradle design or an economy in loops is published by Stahel and Reday (in 1982 repeated in a book), also reporting the 'three pillars of sustainable development' ecologic, economic and social compatibility.

1984 Acid rain has become a large environmental issue and measurements are taken by the government. The emissions of Sulphur oxides have to be reduced by 70%. Emissions of Nitrogen oxides have to be reduced by 30% and of ammonia with 50% by the year 2000.

1987 Brundtland Report, also called Our Common Future, publication released by the World Commission on Environment and Development (WCED) introduces the concept of sustainable development and describes how it could be achieved. Sponsored by the United Nations (UN) and chaired by Norwegian Prime Minister Gro Harlem Brundtland.

1987 More influence by environmental NGO's. Heineken is not allowed to dispose yellow crates with cadmium-based colourants.

1987 A big discussion about one-way packaging versus returnable packaging starts and Life Cycle Assessments are used to find the best solution. Many people cannot believe that a one-way beverage carton for milk is more sustainable than a reusable glass bottle.

1987 Ngo's start a ban on the use of PVC, related to dioxins found in milk produced in the surroundings of waste incinerators.

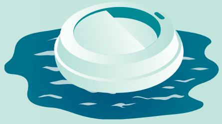
1988 Report "Zorgen voor Morgen" (Worries of tomorrow) in which the current situation of the environment in the Netherlands is described. The start for environmental based measures.

1989 The Montreal Protocol on Substances that Deplete the Ozone Layer (a protocol to the Vienna Convention for the Protection of the Ozone Layer) - a treaty to protect the ozone layer by phasing out the production of numerous substances (first CFCs, later HCFCs, HPMPs and HFCs) responsible for ozone depletion.

1989 Nationaal Milieubeleidsplan (NMP, NL), plans by the Dutch Governement with environmental targets up to 2010. Also Covenant packaging (NL) is part of the NMP.

1990 Start of the Duale System Deutschland: companies are responsible for used packaging and must take back packaging waste, first tertiary packaging, followed by secondary and later primary packaging. The Grüne Punkt was used to show consumers which primary packaging were part of the system.

1990's Modified Atmosphere Packaging adopted on larger scale. Although the technique is very old it was mainly used for bulk transport of fruit. Oxygen sensitive products like meat, chicken, fish, nuts, coffee, bakery products, fresh meals, fresh salads etc. were adopted at large scale and changed the landscape of packaging. Freshness of products became common.



1995 2000 2005 2010 2015 2020

2019 PFAS (polyfluoroalkyl) substances are introduced as environmental and cause delay for many projects.

2019 Emission of nitrogen oxides is related to Natura 2000 protected areas. The discussion shows that cows and farming are one of the largest emission sources.

2019 Single Use Plastics Directive is accepted with a ban on plastic items.

2016 The new plastics economy, rethinking the future of plastics - World Economic Forum, Ellen MacArthur Foundation and McKinsey & Company.

2015 UNEP report concerning biodegradable plastics and marine litter spends attention to (micro) plastics in oceans, rivers and on beaches.

2015 United Nations (UN) definition of Sustainable Development Goals (SDGs).

2011 A research showes that mineral oils used in printing inks causes food safety issues. The first serious case showing that large scale recycling needs attention from the viewpoint of food safety.

2008 In the Netherlands companies were made responsible for packaging and packaging waste and have to take back packaging after use.

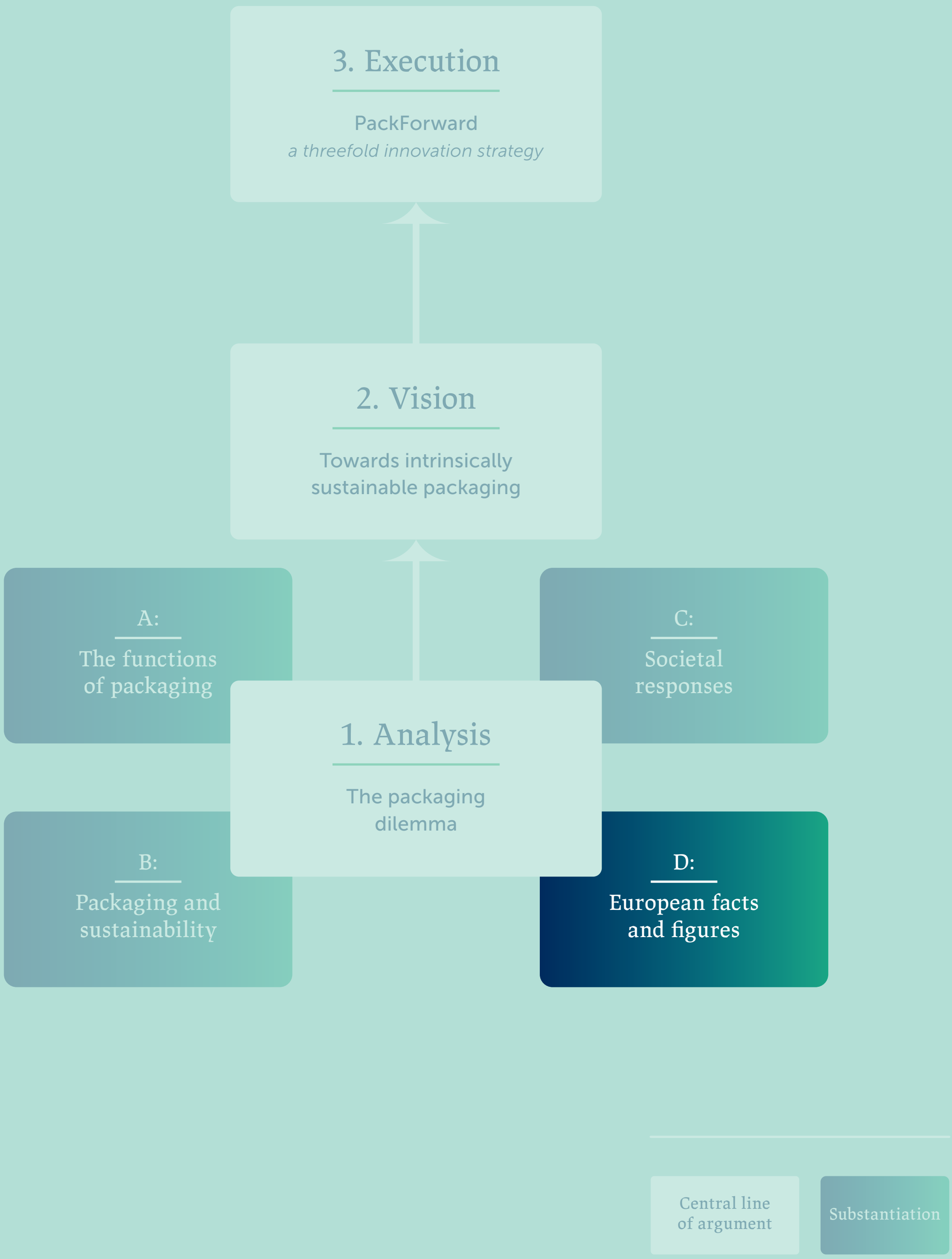
2000 Emissions of particle matter was more over seen as a health issue. Measures have to be taken by companies to reduce the emissions of particle matter.

1996 Covenant II is redefined on base of the Packaging and Packaging Waste Directive.

1994 European Directive on Packaging and Packaging Waste (EC 94/62) with Essential Requirements and Harmonised Standards which account for companies.

1992 Agenda 21 gets adopted in Rio de Janeiro to build a global partnership for sustainable development.

STEPS IN THE DEVELOPMENT OF SUSTAINABILITY AWARENESS RELATED TO PACKAGING


3. Execution
PackForward
a threefold innovation strategy
2. Vision
Towards intrinsically sustainable packaging
A:
The functions of packaging
C:
Societal responses
1. Analysis
The packaging dilemma
B:
Packaging and sustainability
D:
European facts and figures
Central line of argument
Substantiation

Chapter

D

European facts and figures

D.1 Introduction

In this chapter, we will describe the facts and figures in relation to the European packaging market, with a strong emphasis on plastic packaging. We will use the packaging value chain as a reference to describe Europe's current situation *(see Figure 27)*. Each part of the value chain will be addressed:

1. Raw materials
2. Packaging materials
3. Packaged products
4. Usage
5. Collection
6. (Marine) Litter
7. Sorting
8. Recycling

During every step of the chain, there can be losses and import and export of materials. We describe the packaging market with the help of these chain steps. We have limited the scope of the analysis to six countries that together represent 70%[90] of packaging material that is put on the market: Belgium, Germany, France, Italy, the Netherlands and the United Kingdom. We also compare these figures to average scores of the twenty-eight member states of the European Union.

After discussing each step of the chain, we will analyse the chain's yield for plastics: how much material was recycled and used as a new resource?

D.2 Raw materials

Our society uses large quantities of raw materials for a wide range of purposes (construction, infrastructure, packaging materials, etcetera). *Figure 28* illustrates how many kilograms of the various raw materials that are produced per person per year in Europe. Furthermore, the table shows the percentage of each raw material that is used for the production of packaging materials. For example, only a small percentage of the total weight of wood and metal is used for the production of packaging materials. These percentages are higher for paper, glass and plastic.

FIGURE 27 - OVERVIEW OF THE CHAIN STEPS FOR PACKAGING MATERIALS.

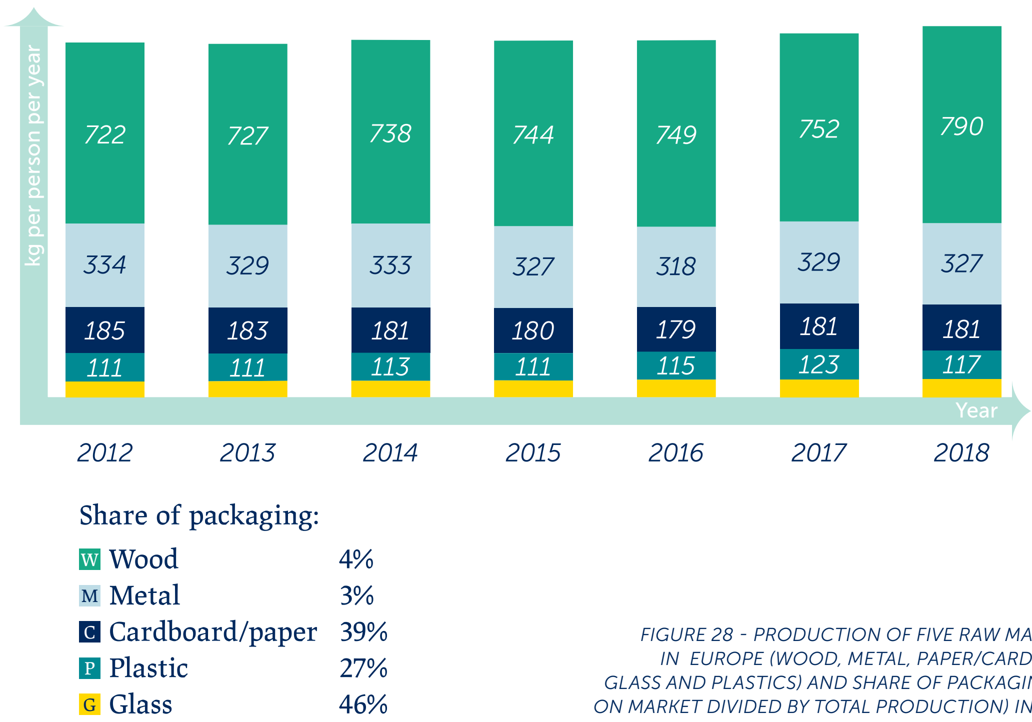


FIGURE 28 - PRODUCTION OF FIVE RAW MATERIALS IN EUROPE (WOOD, METAL, PAPER/CARDBOARD, GLASS AND PLASTICS) AND SHARE OF PACKAGING (PUT ON MARKET DIVIDED BY TOTAL PRODUCTION) IN TABLE .[91]

Plastics

In Europe, about 40% of all plastic converter demand is being used for packaging.[92] This makes packaging the largest market sector for plastics. This number has been steady for the past years.[93] The life span in regard to use remains short: plastics in packaging have the shortest life of all products *(see Figure 29)*.

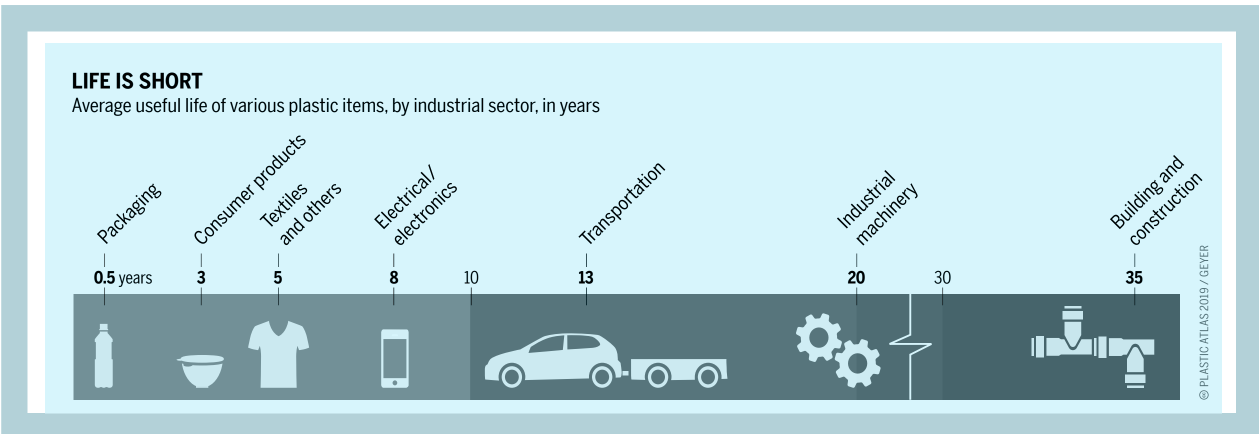


FIGURE 29 - PLASTICS FOR PACKAGING HAVE THE LARGEST SHARE OF INDUSTRY, BUT THE SHORTEST LIFETIME SPAN.[94]

Worldwide, the production and consumption of plastics has been increasing continuously since the 1970s and is expected to keep growing until the year 2050 *(see Figure 30)*. To produce these plastics today, we largely depend on virgin raw material derived from fossil resources. A small percentage of the raw materials used for the production of plastic comes from recycling (see section D.6 for more information). At the moment, the use of bio-based resources for the production of plastics only occurs on a very small scale (1% in 2015 in the Netherlands[95]). *Box 20* covers the (possible) future role of bio-based materials in the production of plastics in more detail.

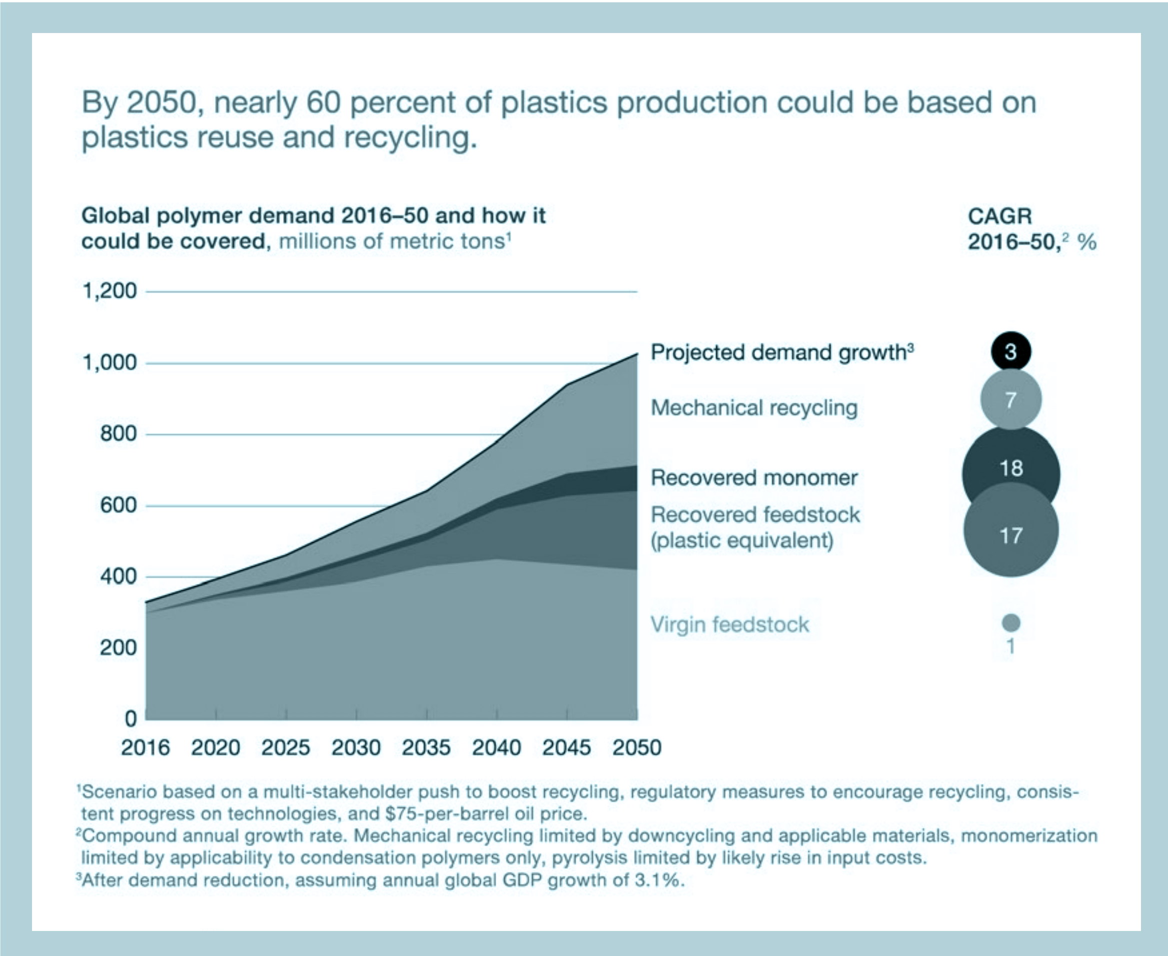


FIGURE 30 - GLOBAL POLYMER DEMAND 2016-2050 AND HOW IT COULD BE COVERED (ACCORDING TO MCKINSEY).[96]

In the future, there will be an increase in the use of resources for the production of plastics other than fossil based raw materials.

Box 20: Alternative sources for fossil based raw materials

Bio-based

Currently, only 1.5% of plastics in the Netherlands is produced using bio-based materials.[97] According to the Dutch Government, one of the key elements of a circular economy, is to maximize the use of sustainable produced and renewable resources such as biomass.[98] The aim is to increase bio-based plastics to 15% in 2030.[99] Legal barriers to apply bio-based and recycled resources in packaging are limited, except for food packaging.[100]
"The main applications of bio-based and biodegradable plastics are currently in (food) packaging, food service ware, (shopping) bags, fibres/nonwovens and agricultural applications. (..) The three most commonly used bio-based plastics with unique properties are PLA, starch-based plastics and cellophane."[101]

Chemical recycling

Chemical recycling is a collective name for various processes that each reintroduce plastics at a different moment in the chain: polymers are broken down into monomers or molecules that form the basis for e.g. new plastics. The various chemical recycling processes each have their own requirements in regards to the input stream of plastics (packaging materials) and result in different outputs. Chemical recycling is given a lot of attention at the moment because it offers various (possible) benefits:[102]

- Chemical recycling makes it possible to separate various types of plastic out of a single product or packaging, or separate plastic from other materials or resources.
- The outputs of chemical recycling processes can often be used for the production of new food-grade plastic packaging materials. This is important for major manufacturers who have ambitions regarding the use of recycled plastics in their packaging materials.
- Chemical recycling can handle relatively complex streams of different materials and any adherent moisture.
- In pure plastic streams, chemical recycling can handle difficult forms of contamination or pollution (e.g. additives, odours and colours).

In the Netherlands (as in several other countries), various chemical recycling initiatives are being developed. This method of recycling is currently undergoing significant expansion, particularly because several major parties (e.g. BASF, Shell and Unilever) take part in this development in various ways.

"Although there is a role for chemical recycling, it's not a silver bullet. Instead of focusing on the package technology or the technology of the processes, or the R&D of it, the dominating discussion should revolve around the economics of it."

Tom Szaky,
CEO at TerraCycle
United States

Mechanical recycling and use of recycled material

Mechanical recycling involves using mechanical techniques to recycle packaging materials after use. To realise this, the packaging materials must usually first be collected and sorted. Recycling refers to any useful application with which waste materials are reprocessed into raw materials, materials and products with the same or a different purpose.

Recycling saves resources. On top of that, making new materials from recycled raw materials is generally a far more energy-efficient proces compared to making new materials from virgin raw materials. Recycling also ensures there is less waste that has to be incinerated or which might end up as landfill or litter. It is therefore important to keep raw materials in the packaging chain as long as possible. Using recycled raw materials is an important option when it comes to making packaging materials more sustainable. By using recycled raw materials for a packaging, the use of new (virgin) raw materials can be avoided.

Nevertheless, it is a challenge to close the business case for recyclate; firstly, because recycling is a costly process and secondly, because the revenue of recyclate is linked to the oil price, while the costs are not. This means that when oil prices drop, the revenue of the recyclate also drops while the costs remain high.[103]

D.3 Packaging materials, packaged products and consumption

Over the past decades, the amount of packaging we produce and use as society, has increased. In *Figure 31*, a steady growth of packaging put on the market can be seen for EU-28 and the six selected countries. This increase has been driven by trends such as urbanisation, changing consumption habits and internationalisation (for more background information, see Chapter A).

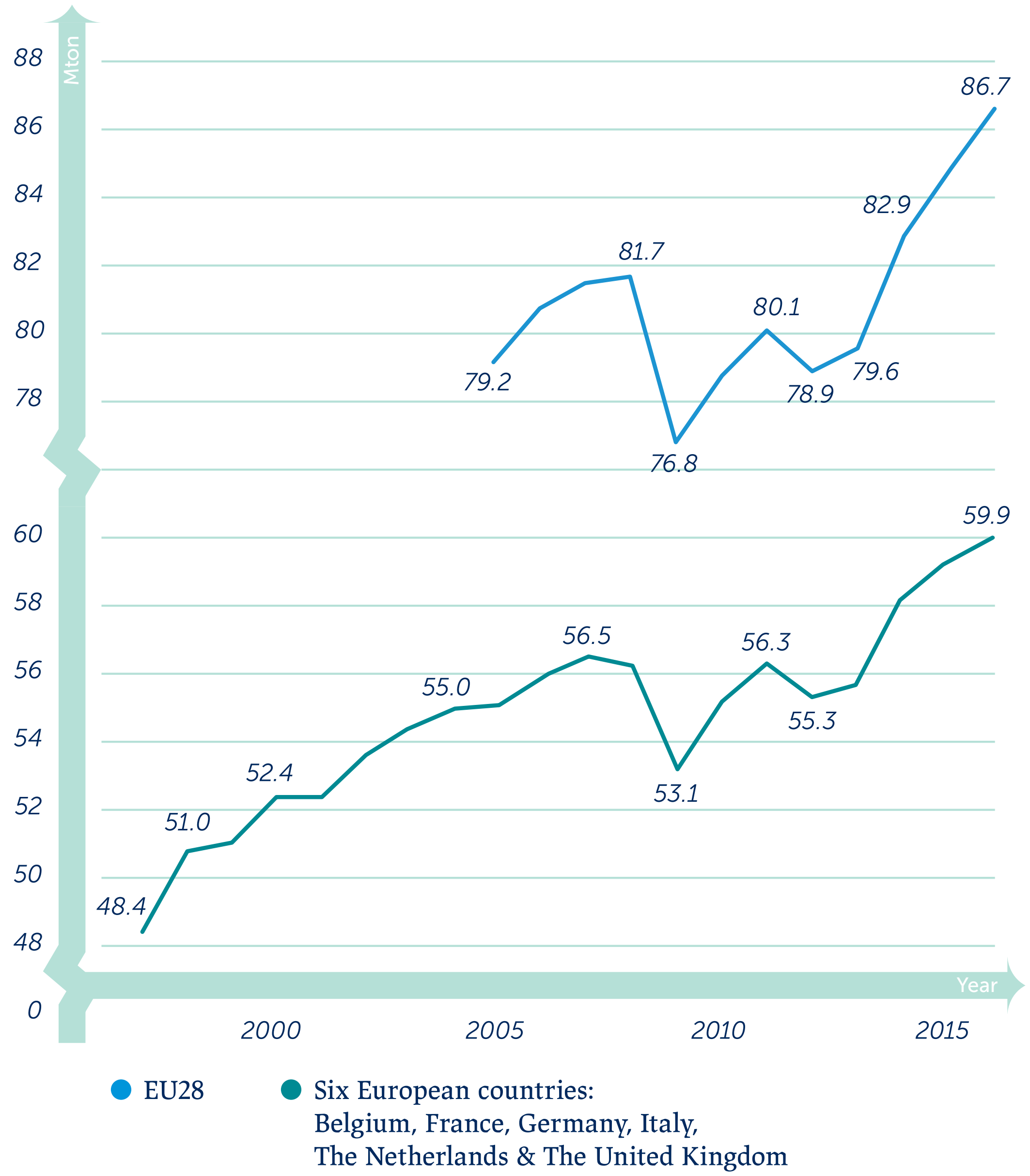


FIGURE 31 - THE TOTAL AMOUNT OF PACKAGING PUT ON THE MARKETS OF EU28 AND THE SIX SELECTED EUROPEAN COUNTRIES (MTON/YEAR) [104] .

As shown in *Figure 32*, the most commonly used packaging material in Europe (by weight) is cardboard/paper, with the average person using 69 kg per year (35,4Mton in total) in 2016. Glass, plastic and wood are equally common in packaging, at approximately 30 kg/person/year, whereas we only use about 9 kg of metal packaging per person, per year. There is an increase in the use of paper and cardboard, plastic and wood packaging for the (increasing) use of packaging in Europe, while the use of metal and glass have decreased.

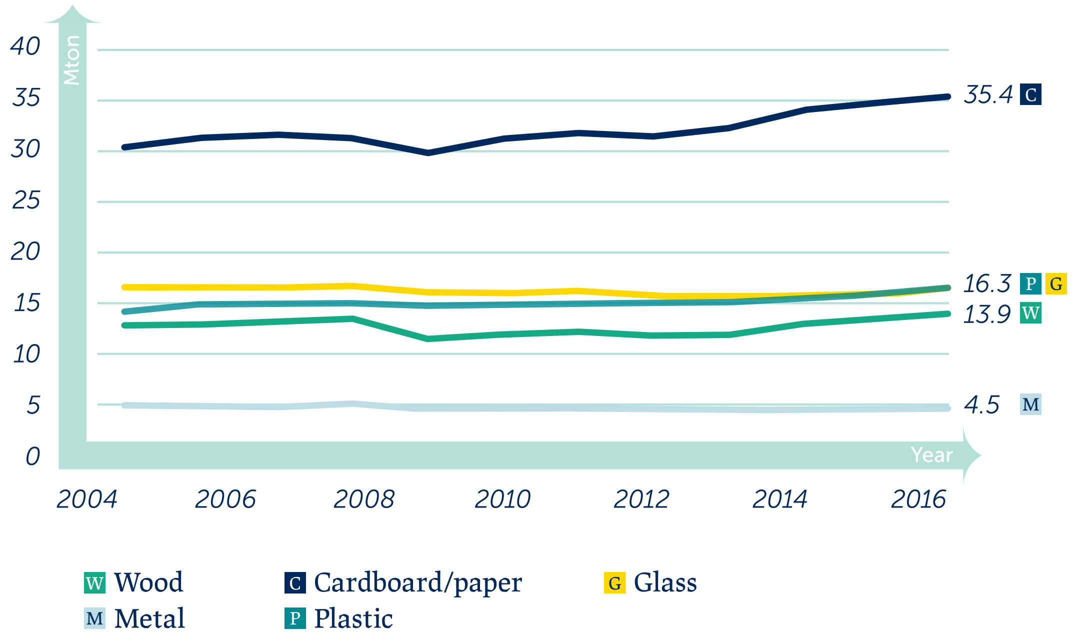


FIGURE 32 - THE AMOUNT OF PACKAGING USED (BY WEIGHT) PER MATERIAL IN THE EUROPEAN UNION IN THE PERIOD 1997-2016 . 105

In the last 20 years, the amount of plastic packaging used in the six aforementioned countries has grown from 7,4 Megatons to 10,6 Megatons, an increase of around 43%. The amount (kg) of plastic packaging used per person per year has also increased over the years.

D.4 Collection, sorting and recycling

In Europe, most packaging materials are collected after disposal by the consumer. Generally speaking, two collection systems are used: source separation and collection via residual waste. For materials collected as part of the residual waste stream, post separation can be applied to extract a number of different packaging materials from the residual waste stream. The materials obtained from source separation and post separation are then sorted. Across Europe, few countries have post separation infrastructure in place. If post separation is used it is mainly for plastic and metal packaging. The collected and/or sorted material is used as input for recycling. During the last decade, the recycling rate of all packaging materials has been around 70 to 80% in Belgium, Germany and the Netherlands. The recycling rate in France, Italy, United Kingdom, and the EU-28 average has risen towards that same level *(see also Figure 33)*.

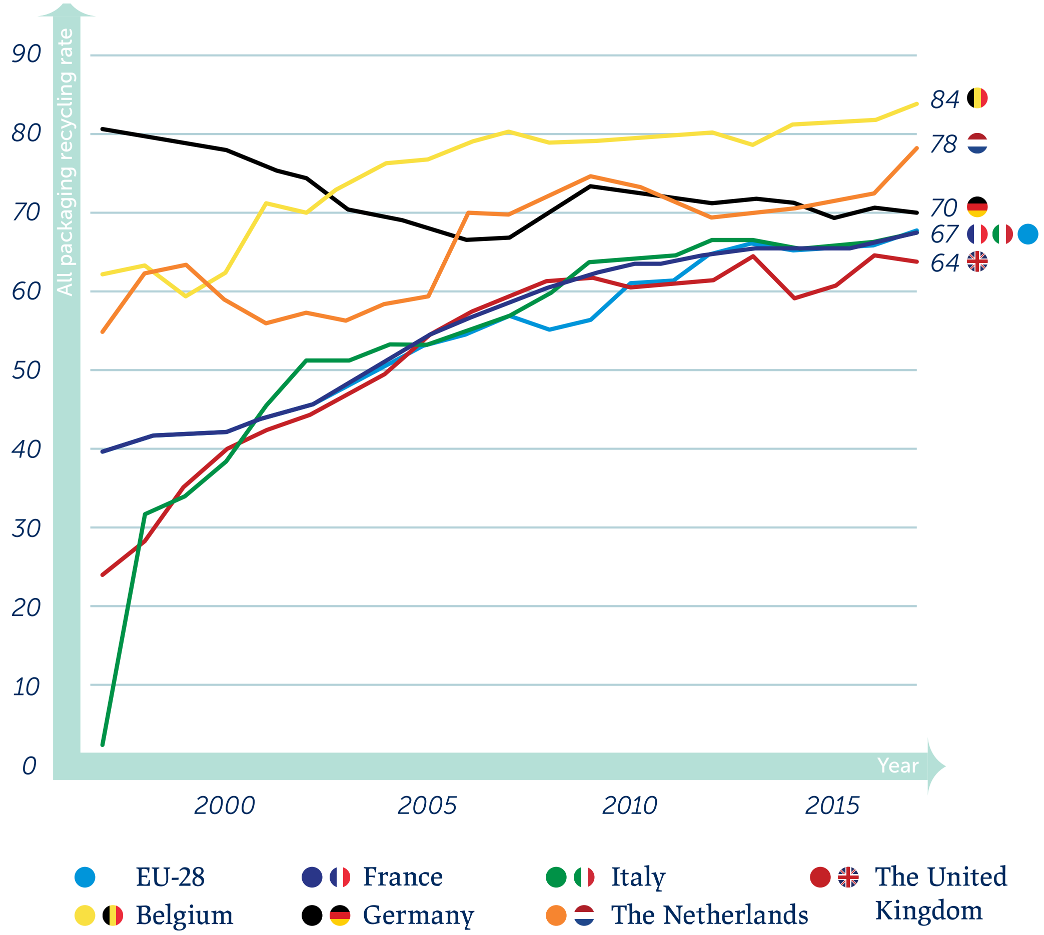


FIGURE 33 - PACKAGING RECYCLING RATE IN SIX EUROPEAN COUNTRIES AND THE AVERAGE OF THE 28 EU COUNTRIES OVER THE PERIOD 1997-2016 .[106]

The materials which are most commonly recycled in all countries are glass, paper & cardboard and metal *(see also Figure 34)*. Belgium, Germany and the Netherlands achieve recycling rates for these materials higher than 80%.

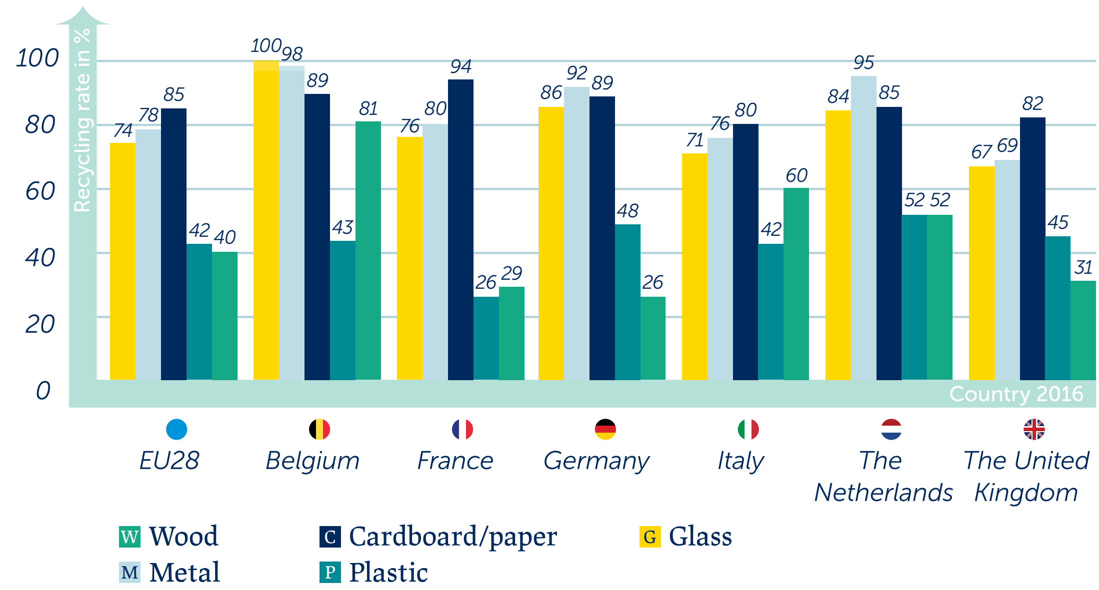


FIGURE 34 - PACKAGING RECYCLING RATE PER MATERIAL IN SIX EUROPEAN COUNTRIES AND THE AVERAGE OF THE 28 EU COUNTRIES IN 2016 .[107]

Across all countries, plastic and wood are the least commonly recycled materials. Their recycling rates are significantly lower than the overall recycling rate (all materials together). For example, in the Netherlands the overall recycling rate for packaging is 73% versus a plastic packaging recycling rate of 52%. In Europe (EU-28), the overall recycling rate for packaging is 67% versus a plastic packaging recycling rate of 42%.

These recycling percentages are calculated based on the weight of the waste material when it arrives at the 'gate' of the recycling facility (corrected for non-packaging materials and contaminants if these are above allowed limits). However, this measurement point has recently been revised and thus will change in the foreseeable future *(see Box 21)*.

Box 21: New point of calculation for recycling

The European Commission has recently revised the packaging directive, see also Chapter C. One of the revisions concerns the measurement point for recycling, which will change. In the new situation, the weight of recycling is measured when waste is approved and qualified for recycling and about to enter the recycling process. For plastics, for example, this could mean that packaging may only be classified as recycled if it can be used to produce flakes or granulate. With the current measurement point a recycling rate of 42% for plastic packaging is achieved in Europe. Based on current estimates of recycling yields this would only be 29% if the new measurement point is applied. This is a significant drop *(see also Figure 35)*. The new European recycling targets (50% in 2025 and 55% in 2030) however are calculated according to this new measuring point. This calls for a substantial change in how plastic packaging is designed and how we manage our plastic waste.[108]

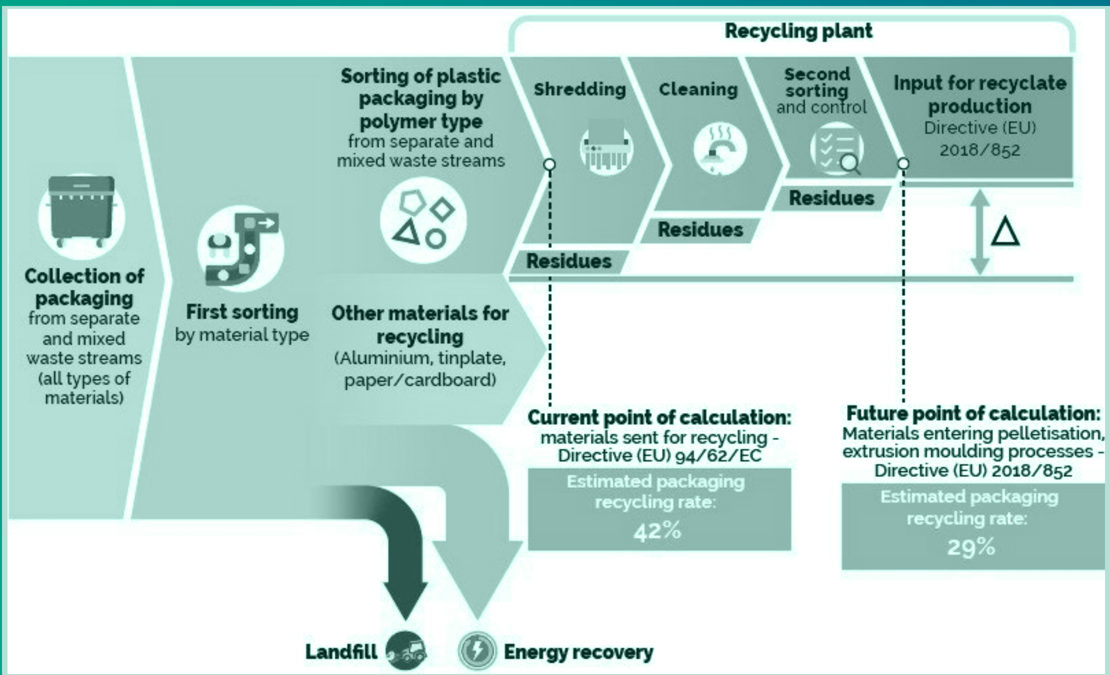


FIGURE 35 - PROCESS OF PLASTIC PACKAGING RECYCLING FROM PLASTICS EUROPE.[109]

However, the new measurement point is still focused on the quantity of recycling, instead of the quality of recycling (the possible applications for the material). Thinking about the use of recycled content for food-grade applications for example, it is clear that more effort is needed to achieve a similar recycling rate with higher quality output material. Companies that produce recycled plastic that will come into contact with food products may only use approved materials and processes which have been authorised by the European Food Safety Authority (EFSA). Critical aspects of a material's approval are the characteristics of the plastic that is to be recycled and the "cleansing ability" of the recycling process itself. At the moment, almost the only recycled plastic available in food-grade quality is recycled PET.

This past decade, countries such as the United States, Japan and most EU-countries relied on the export to especially China to process and recycle various waste streams. As a result of stricter pollution standards, the export of plastic waste came to a halt. For more information see *Box 22*.

Box 22: International trade of plastic waste

Since 2000, a lively trade in plastic waste has emerged in Europe, as can be seen in *Figure 36*. Germany and the United Kingdom are major net exporters, while the Netherlands and Italy are net importers.

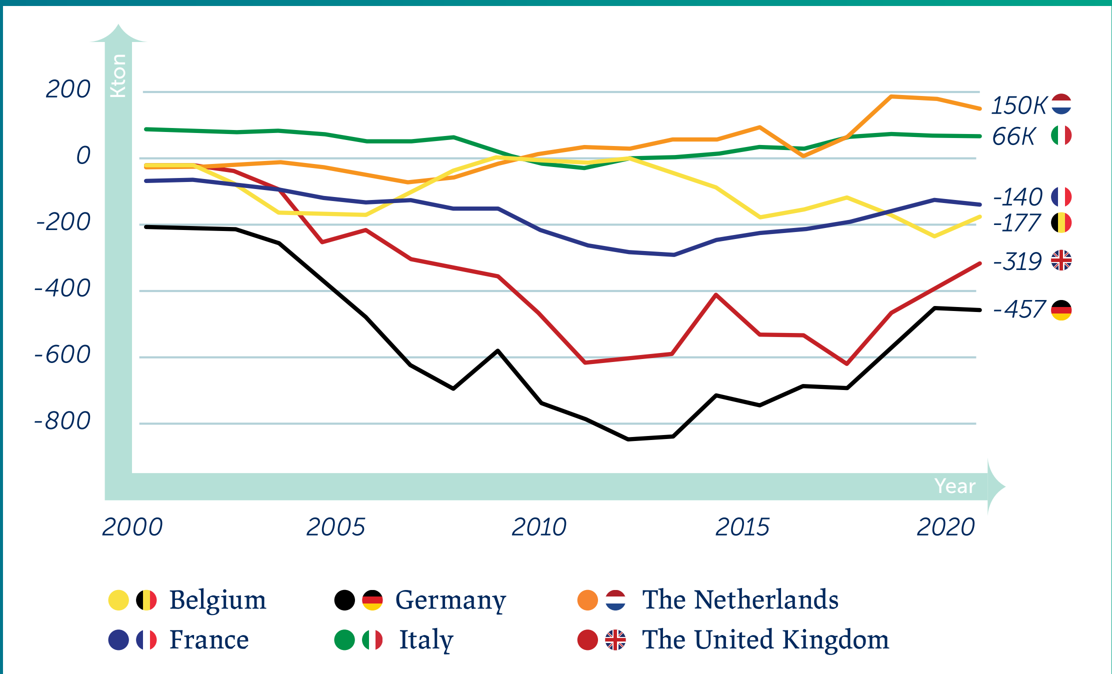


FIGURE 36 - NET IMPORT OR EXPORT OF PLASTIC PACKAGING WASTE IN SIX EUROPEAN COUNTRIES IN 2000-2020.[110]

Due to various reasons (often different per country) the recycling of plastic (packaging) waste streams was outsourced to the far east, and in particular to China. The export of plastic waste to China increased tremendously for 20 years, before declining significantly, with exports from the six European countries evaporating from € 484 million in 2012 to € 25 million in 2018. The ban on importing plastic (packaging) waste and many other waste streams in China in 2018 has quickly been followed by import bans by other Asian countries. With the sudden disappearance of such an important recycling outlet and the lack of alternatives, the material has accumulated in the different European countries. These countries now realise how dependent they were on the huge and often cheap processing facilities in Asia. Europe must now not only process all of its own waste and thus has to seriously increase the processing capacity available, but it also faces and has to act upon the increase in recycling costs compared to when recycling was outsourced to Asia.

In case packaging has been collected but not recycled, it is either sent to a landfill or to a waste furnace or waste-to-energy plant. In Belgium, Germany and the Netherlands packaging waste which is not recycled, will likely end up in a waste-to-energy plant. In France (24%), Italy (22%), the United Kingdom (28%) and EU-28 (20%) a significant percentage of packaging waste is sent to a landfill in comparison to 1% in Germany and the Netherlands.[111]

D.5 (Marine) Litter

No European data is available regarding the volume of plastic packaging materials in litter. In some cases, the total volume of litter is known (e.g. in France), but it is not possible to determine the percentage of packaging materials.

Earlier research conducted in the Netherlands[112] suggests that circa 1-2% of all disposed plastics end up as litter. That amounts to nearly 20% of the total volume of litter.

In regards to plastic in the marine environment, Jambeck et al[113] presents a general overview, showing the percentage each country contributes to the marine pollution of plastics (all plastic pollution is taken into account here). This research shows that the European Union's total percentage amounts to 1% of the global total, which is around 89 kilotons per year.

Since information about litter is limited, it is not possible to take the impact that materials have on the different environments into consideration when comparing the different materials with regard to their environmental impact. Many LCA studies therefore ignore the various litter issues.

D.6 Available data

The chain steps for packaging materials were presented in the introduction. For each chain step *(see Figure 37)*, we analysed the extent to which information is publicly available for the six countries and for EU-28. When measuring progress of the transition towards a recycling- or circular economy, the availability of robust data is key. Data which show the flow of materials from the cradle to the grave and all steps or processes in between. Only then can one intervene and measure the change or improvement.

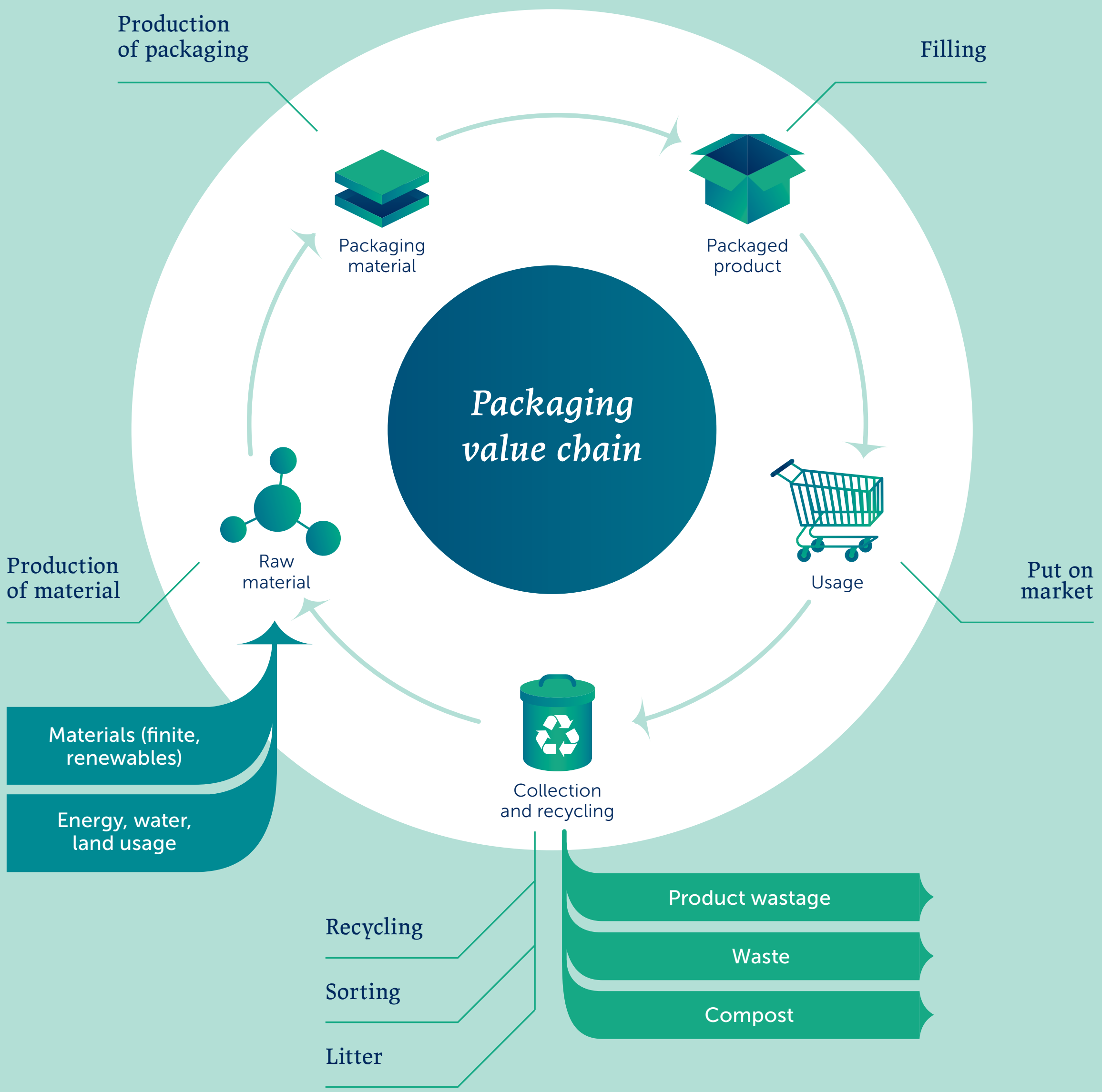


FIGURE 37 - PACKAGING CHAIN STEPS ANALYSED FOR AVAIABLE INFORMATION.

Analysis of the available public sources reveals the following:
- There are no registrations that record all steps of the packaging chain in conjunction with each other.
- Instead, data from different registrations must be combined.
- The various registrations differ in regard to their scope and definitions. This therefore does not result in an accurate mass balance.
- Data within a chain step are usually not available about all aspects, e.g. subtypes or applications.
- Any data that is structurally available, usually only pertains to the output or input of a specific chain step. In particular, there is little insight into the yield of recycling and export of material in most steps of the chain is hardly monitored at all.

"In the current system in the Netherlands recycling is important, but there is more: reduce and reuse are also part of it just as transparency of information and a critical eye on companies claiming certain sustainability performances of their packaging."

Roald Lapperre,
Director-General for the Environment and International Affairs at the Dutch Ministry of Infrastructure and Water Management

D.7 Yield plastic packaging chain

The yield of plastic packaging materials per chain step has been estimated based on the available sources and various presumptions *(see Figure 38)*. Please note that the scope in this paragraph is broader than what is considered when reporting recycling rates *(see Figure 34)*.

Reported recycling rates are currently calculated by dividing the *collection and recycling* figure by the packaging put on the market figure *(see Figure 38 and 39)*. Therefore, the yield figures presented in this paragraph are lower than the recycling rates reported.

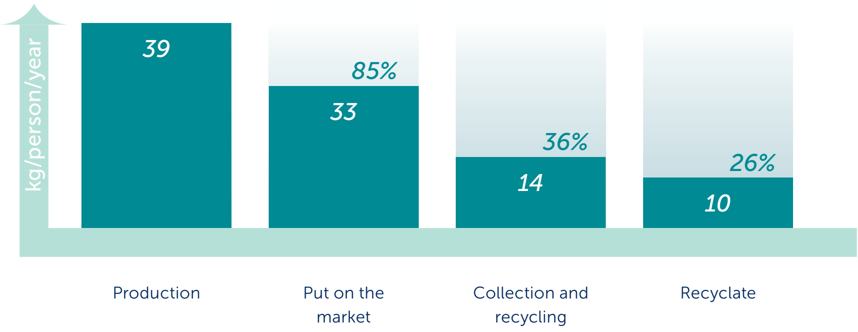


FIGURE 38 - VOLUMES OF PLASTIC PACKAGING PER CHAIN STEP IN THE EUROPEAN UNION.[114]

In Europe, 123 kg of plastics is produced per person per year. Of this total, 39 kg is used to produce packaging, of which 33 kg ends up as 'put on the market'. Of all plastic used for the production of packaging materials in the EU, circa 26% comes back in the form of recycled material *(see Figure 38)*. In the Netherlands the yield of the recycling of plastic packaging materials is with its 25% comparable to the European percentage (11/44 kg per person per year) *(see Figure 39)*. However, it must be noted that the drop between the chain steps 'production' and 'put on the market' is twice as large in the Netherlands as it is for the EU. Earlier research has also shown that the loss[115] of materials during the various steps of the chain is important and mainly takes place during the collection and sorting phases in the collection and recycling step.

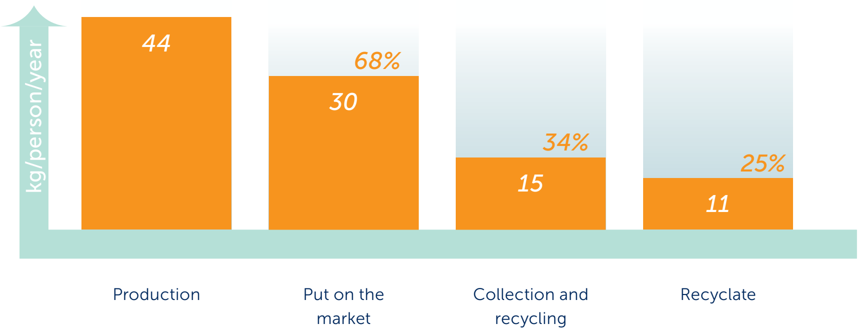


FIGURE 39 - VOLUMES OF PLASTIC PACKAGING PER CHAIN STEP IN THE NETHERLANDS.[116]

D.8 What do the facts and figures tell us?

This chapter of *The State of Sustainable Packaging* describes the volumes that are released on the European packaging market, broken down per material and per chain step. The overall picture is that packaging materials are made primarily from virgin raw materials. In the meantime, the use of packaging materials keeps increasing and consequently with that the amount of material needed to produce them. There has not been a break in this trend yet.

Furthermore, up-to-date data pertaining to the different steps in the plastic chain is not available from year to year. Therefore, monitoring progress on circularity is not possible. Using the current definition, 42% of all plastic packaging materials put on the market are being recycled. Once the new measurement point is used, this percentage is estimated to drop to about 29%. In other words more has to be done in order to achieve the new recycling targets (50% by 2025 and 55% by 2030). Large efforts are needed to attain the 2025 and 2030 recycling targets, so EU-countries will have to focus most of their resources to be able to reach these targets. If indeed by the year 2025/2030, Europe as a whole attains recycling rates for plastic packaging waste of 50-55%, this means that the remaining and large amount of plastic material will not be recycled and thus will be 'lost' within the plastic value chain. Taking into account the continuous growth of plastic (packaging) consumption, this will mean that the amount of material which must be recycled and the amount of material which is 'lost' will continue to grow.

So, even if the recycling targets for 2025 and 2030 are attained, it will likely not be sufficient. To be able to do so, the way our economic processes are organised should be reconsidered, and innovative pathways towards ecologically smarter modes of production, consumption and packaging should be developed. Modes that intrinsically prevent polluting our biosphere. In short, on top of the problem-reducing innovations offered by recycling, additional innovation tracks are needed for intrinsically sustainable solutions.

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