Final report

Research into the use of recyclate

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Study conducted on behalf of the Federal Public Service Public Health, Food Chain Safety and Environment, Directorate-General Environment.
Specifications nr. 150007

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Samenvatting

Kunststofrecyclaten en recyclaat-inhoud

Kunststofrecyclaten zijn industrieel inzetbare materialen, gemaakt van intern of extern afgedankte polymere producten (kunststoffen, synthetisch textiel, composieten), die tenminste één mechanisch recyclageproces volledig doorlopen hebben. Ze kunnen samen met dezelfde of andere virgin polymeren via een smeltproces verwerkt worden tot nieuwe producten met recyclaat-inhoud.

Kunststofrecyclaten worden onderverdeeld in secundaire grondstoffen voor closed-loop (men maakt opnieuw hetzelfde product) en open-loop (er wordt een ander product gemaakt) recyclage. Deze neutrale termen houden geen oordeel in over de 'hoogwaardigheid' van de recyclage toepassing. Het volgen van een open loop houdt niet automatisch een devaluatie van de waarde van het materiaal in.

"Pre-consumer"- en "post-consumer"-recyclaten kunnen onderscheiden worden naargelang deze recyclaten geproduceerd werden uit producten die al dan niet afgedankt werden door de consument. Welke recyclaten de producent al dan niet in rekening mag brengen voor het berekenen van RC kan contractueel of via een KB vastgelegd worden. Om de circulaire economie voldoende groeikansen te bieden wordt voorgesteld om alle mogelijke recyclaatstromen in rekening te brengen.

De "recycled content" (RC) van een nieuw product kan omschreven worden als de % gewichtsfractie van de ingezette recyclaten in dit product (cfr. EN 14021). Zowel interne als externe recyclaatstromen kunnen in rekening gebracht worden voor het berekenen van RC.

Om voldoende productstabiliteit te kunnen garanderen worden biologisch afbreekbare en composteerbare recyclaten uitgesloten. Recyclaten gemaakt uit oxydegradeerbare polymere producten mogen evenmin ingezet worden.

Minimale eisen te stellen van RC-producten

Via chemische analysetechnieken is het onmogelijk om de "recycled content" van een product te bepalen. Slechts op basis van product- en productiegegevens van de betrokken producent kan men bepalen hoeveel en welke recyclaten er effectief ingezet werden voor de productie van het RC-product.

Om voldoende vertrouwen te geven aan afnemers van RC-producten en consumenten moet deze informatie van de producent uiteraard correct zijn en telkens opnieuw gegarandeerd kunnen worden.

Het wettelijk kader m.b.t. dergelijke RC-producten kan de "minimale eisen" vastleggen waaraan deze producten moeten voldoen om als dusdanig op de markt gebracht te worden. Het studie team stelt het volgende voor:

- Een bepaald gehalte aan recyclaat te garanderen, berekend op de polymeerfractie van het product (inclusief additieven en toeslagstoffen). Dit gehalte is ofwel een minimaal percentage, arbitrair opgelegd door de uitbestedende overheid op basis van het product, ofwel is de hoeveel open, maar wordt deze proportioneel beloond. Om dit gehalte te bekomen

mogen alle recyclaatstromen ingezet worden. Het opgegeven recyclaatgehalte mag echter niet steunen op een éénmalige productie en moet steunen op een objectief vast te stellen naspeurbaarheid- en kwaliteitsbeheersysteem bij de producent, conform EN 15343. Het bestaan en toepassen van dergelijke beheer- en beheersingssystemen kan aangetoond worden via een systeemcertificaat dat geldig is op de van toepassing zijnde RC-producten en toegekend werd door een erkend certificatie-organisme.

- Het RC-product moet voldoen aan de van toepassing zijnde product eigen technische specificaties en andere kwaliteitseisen of wettelijke voorschriften. De productconformiteit moet worden aangetoond op basis van interne kwaliteitscontroles of op basis van een extern analyseverslag van een erkend lab.
- Het RC-product mag niet schadelijk zijn voor de gezondheid van mensen of voor het milieu. Concreet betekent dit dat het RC-product REACH-conform is. Het aantonen van de REACH-conformiteit moet steunen op geldige verklaringen / certificaten van grondstofleveranciers of een erkend lab.

Deze minimale eisen zouden op termijn uitgebreid kunnen worden met bijkomende eisen rond de mogelijke aanwezigheid van nano-additieven zeldzame metalen of andere functionele additieven (o.a. in smart plastics). Daarenboven, zoals normen periodiek herzien worden, moeten deze minimale eisen om de 5 jaar gereviewd worden.

Certificatiesystemen in kader van minimale RC-producteisen.

Het succes van RC-producten wordt in belangrijke mate bepaald door:

- het beleid gericht op het implementeren van een circulair economisch model,
- de kwaliteit, de beschikbaarheid en de prijs van recyclaten,
- de betrouwbaarheid van de gegevens van RC-producten die in dit kader gebruikt worden.

De noodzakelijke gegevens van RC-producten zullen steeds aangereikt moeten worden door de betrokken recyclage- en productiebedrijven.

Om voldoende vertrouwen te geven aan dit ganse proces moet dit steunen op algemeen erkende certificatiesystemen met duidelijke beoordelingscriteria. Zowel product- als bedrijfscertificaten komen in aanmerking. Uiteraard moeten deze certificaten betrekking hebben op de bedoelde RC-producten. Een accreditatie (volgens ISO 17021) van deze certificatie-organisaties zal zorgen voor het noodzakelijke vertrouwen en de creatie van level playing field binnen Europa. Het toezicht op het mogelijk misbruik van certificaten of logo's op RC-producten moet binnen het accreditatiesysteem vastgelegd worden.

Wereldwijd bestaan er een aantal product- en bedrijfscertificatiesystemen die bepaalde aspecten van RC-producten bekijken. Alleen 2 Europese certificatiesystemen (TUV en QA-CER) bekijken de drie minimale eisen van RC-producten.

Belang van productanalyses.

De recyclaat-inhoud (% gewichtsaandeel) van polymere producten zal nooit kunnen bepaald worden via specifieke analyses van RC-producten. Maar om de conformiteit van RC-producten met de andere minimale eisen aan te tonen bestaan er wel concrete en betrouwbare productcontroles en analyses.

Zowel de productconformiteit t.o.v. de technische specificaties en andere kwaliteitseisen zoals de REACH-conformiteit, kan vastgesteld worden aan de hand van het uitvoeren van product/toepassing-specifieke kwaliteitscontroles en adequate chemische analyses door erkende en onafhankelijke instellingen.

Doordat veel producenten niet beschikken over de nodige apparatuur zijn zij niet in staat zijn om deze conformiteiten zelf te bepalen. Externe productcontroles en chemische analyses moeten deze problematiek helpen oplossen en zorgen voor het nodige vertrouwen.

Door het bewaken en beheersen van de verschillende materiaalstromen (virgin polymeren, recyclaten, additieven, …) en het toepassen van verschillende procescontroles kunnen producenten de externe productcontroles en analyses uiteraard beperken, maar niet uitsluiten.

Dergelijke productcontroles en analyses zijn niet alleen belangrijk voor de lokale productiebedrijven, maar ook noodzakelijk voor de invoerders van RC-producten die buiten Europa geproduceerd worden.

Het opzetten van gerichte marktcontroles is noodzakelijk om een "level playing field" te creëren. Deze marktcontroles moeten vooral betrekking hebben op de geldigheid van de certificaten van de gecontroleerde RC-producten en de REACH-conformiteit van de RC-producten.

Problemen en uitdagingen m.b.t. RC-productbeleid.

Het succes van een RC-beleid zal door verschillende elementen bepaald worden. De belangrijkste zijn:

- overleg en betrokkenheid van de recyclage- en productiebedrijven (inclusief chemie) en ook organisaties die (kunnen) instaan voor certificaties bij het uitwerken en implementeren van een RC-beleid.
- goede samenwerking tussen de verschillende betrokken overheden (regionaal, federaal en Europees). Bvb in het kader van openbare aanbestedingen en eventuele discussies over RC binnen Ecodesign, Ecolabel, End-of-Life Vehicles, Good Commercial Practices Directive, Packaging.
- het duidelijk definiëren van het begrip "recycled content", RC-producten en van de materialenstromen die daarbij in rekening gebracht mogen / moeten worden.
- het vastleggen van criteria die door certificatie-instellingen en analyse-labs toegepast moeten worden bij RC-certificatie van producten of van bedrijven die RC-producten produceren en/of vermarkten.
- het aanmoedigen van grondstofrecyclage en van de productie van RC-producten. In dit kader is het belangrijk om zo snel als mogelijk EoW-criteria voor recyclaten te laten goedkeuren op Europees niveau, alsook om algemeen aanvaardbare oplossingen te vinden voor het recycleren van producten met SVHC's. Het aanmoedigen en ondersteunen van RC-gerichte innovatieprojecten en "design for / from recycling"-technieken kan het geheel katalyseren, net zoals het opvolgen van de specifieke uitdagingen
- de aankopen / aanbestedingen van de overheden richten op RC-producten die dezelfde performantie hebben en niet significant duurder zijn als de analoge producten op basis van virgin materialen.
- het doorvoeren en opvolgen van marktcontroles.

De principes van Recycled Content zijn in theorie overdraagbaar naar andere materiaalgroepen (papier, metaal, hout…). Echter, het specifieke karakter van kunststoffen zorgt ervoor dat deze huidige aanbevelingen niet zomaar integraal kunnen getransponeerd worden naar deze andere

groepen.

Résumé

Plastiques recyclés et contenu recyclé

Des plastiques recyclés sont des matériaux applicables en industrie, réalisés sur base des déchets polymères internes ou externes (matières synthétiques, textiles synthétiques, composites), qui ont déroulé au moins un cycle entier de recyclage mécanique. Elles peuvent être transformées à l'aide d'un processus de fusion avec des polymères vierges identiques ou différents dans le but de produire des nouveaux produits contentant un certain taux de matières recyclées.

Les matières recyclées synthétiques peuvent être subdivisées en matières premières secondaires à usage en boucle fermée (fabrication de produits identiques) et en boucle ouverte (fabrication de produits différents). Ces termes neutres ne comportent aucun jugement par rapport à la qualité de l'application de recyclage. Le processus de boucle ouverte ne signifie pas automatiquement une dévaluation de la valeur du matériau.

La distinction entre les matières recyclées « pré-consommateur » et « post-consommateur » se base sur la question si les matières recyclées sont produites à partir de produits mis au rebut par le consommateur ou non. Un contrat ou un arrêté royal peut déterminer les matières recyclées qu'un producteur peut prendre en compte dans son calcul du CR. Afin de donner suffisamment de chances de croissance à l'économie circulaire il est proposé de prendre en compte tous les flux de matières recyclées.

Le contenu recyclé (CR) d'un nouveau produit s'exprime en le % de la fraction du poids des matières recyclées dont le produit est composé (cf. EN 14021). Tant les flux internes qu'externes de matières recyclées sont pris en compte pour le calcul du CR.

Pour assurer la stabilité du produit, les matières recyclées biodégradables et compostables sont exclues ainsi que les matières recyclées sur base de polymères oxydégradables.

Exigences minimales auxquelles les produits CR doivent répondre

Il est impossible de déterminer le contenu recyclé d'un produit par des techniques d'analyses chimiques. Uniquement les données relatives aux produits et à la production qui sont fournies par le producteur en question permettent de déterminer la quantité et la nature des matières recyclées qui ont effectivement été utilisées pour la production d'un produit CR.

Pour gagner la confiance des acheteurs et consommateurs de produits CR, les informations des producteurs doivent évidemment être correctes et garanties à chaque reprise.

Le cadre légal concernant de tels produits CR doit définir les "exigences minimales" auxquelles les produits CR doivent répondre pour être ainsi commercialisés.

L'équipe chargée de l'étude propose le suivant :

- Garantir un contenu recyclé déterminé, calculé sur base de la fraction polymère du produit (y compris les additifs et matériaux de rembourrage). Ce contenu est soit un pourcentage minimal, exigé par l'autorité sous-traitante sur la base du produit, soit un contenu ouvert, mais récompensé de manière proportionnelle. Pour atteindre ce taux, tous les flux de matières recyclées peuvent être appliqués. Cependant, le contenu recyclée ne peut pas être calculé sur base d'une production unique et doit s'appuyer sur un système objectif de traçabilité et de gestion de la qualité chez le producteur, conformément à l'EN 15343. La mise en place et l'application de tels systèmes de gestion et de contrôle peuvent être démontrées par un certificat du système valable pour les produits CR d'application et délivré par un organisme de certification agréé.
- Le produit CR doit satisfaire aux spécifications techniques qui sont d'application pour le produit et à d'autres exigences de qualité ou dispositions légales. La conformité du produit doit être démontrée sur base de contrôles de qualité interne ou sur base d'un rapport d'analyse externe effectuée par un labo agréé.
- Le produit CR ne peut pas nuire à la santé des personnes ou à l'environnement. Concrètement, cela signifie que le produit CR doit être conforme aux exigences de REACH. La conformité aux exigences de REACH doit être démontrée en s'appuyant sur des déclarations/certificats valables des fournisseurs de matières premières ou par un labo agréé.

Au fil du temps, il devrait être possible de compléter ces exigences minimales par des exigences supplémentaires en ce qui concerne la présence possible de nano-additifs, de métaux rares ou d'autres additifs fonctionnels. De plus, tout comme la révision périodique de normes, ces exigences minimales doivent être révisées tous les cinq ans.

Système de certification dans le cadre des exigences minimales relatives aux produits CR.

Le succès des produits CR est déterminé de manière importante par :

- la politique axée sur l'implémentation d'un modèle d'une économie circulaire
- la qualité, la disponibilité et le prix des matières recyclées
- la fiabilité des données relatives aux produits CR qui sont utilisés dans ce cadre

Les données nécessaires relatives aux produits CR devront toujours être fournies par les entreprises de recyclage et de production concernées.

Pour créer une confiance suffisante dans ce processus dans son entièreté, il doit s'appuyer sur de systèmes de certification généralement reconnus aux critères d'évaluation clairs. Tant des certificats de produits que des certificats d'entreprises entrent en ligne. Il est évident que ces certificats devront avoir trait aux produits CR en question. L'accréditation (selon l'ISO 17021) des organismes de certification suscite la confiance nécessaire et permet d'assurer des règles identiques au niveau européen en Europe. Le contrôle d'abus éventuels de certificats ou de logos sur des produits CR doit être défini par le système d'accréditation.

Au niveau mondial, il existe un nombre de systèmes de certification de produits et d'entreprises qui vérifient certains aspects relatifs aux produits CR. Seulement deux systèmes de certification européens (TUV et QA-CER) vérifient les trois exigences minimales des produits CR.

L'importance des analyses de produits

Il ne sera jamais possible de déterminer le contenu recyclé (% en poids) des produits polymères

en s'appuyant sur des analyses spécifiques des produits CR. Mais la conformité des produits CR à d'autres exigences minimales peut être démontrée à l'aide de contrôles et d'analyses concrets et fiables existants.

La conformité du produit aux spécifications techniques ainsi que la conformité à d'autres exigences de qualité telles que la conformité aux exigences REACH, peuvent être vérifiées en effectuant des contrôles de la qualité spécifiquement liée au produit/à l'application et des analyses chimiques adéquates par des institutes reconnus et indépendants.

Etant donné que de nombreux producteurs ne disposent pas de l'appareillage nécessaire, ils ne sont pas en mesure de déterminer ces conformités eux-mêmes. Des contrôles de produits et des analyses chimiques externes doivent résoudre ce problème et susciter la confiance nécessaire.

Le contrôle et la gestion des différents flux de matériaux (polymères vierges, matières recyclées, additives,…) et la mise en place de différents contrôles de processus permettent bien sûr aux producteurs de limiter le nombre de contrôles de produits et d'analyses à être effectués par des organismes externes, sans pour autant les exclure.

De tels contrôles de produits et analyses ne sont pas seulement importants pour les entreprises de production locales, mais aussi nécessaires pour les importateurs de produits CR produits en dehors de l'Europe.

La mise en place des contrôles de marché ciblés est nécessaire pour assurer que les règles soient identiques pour tous les acteurs (level playing field). Ces contrôles de marché doivent surtout avoir trait à la validité des certificats des produits CR contrôlés et à la conformité REACH des produits CR.

Problèmes et défis concernant la politique de produits CR

Le succès d'une politique CR sera déterminé par plusieurs éléments, dont les plus importants sont :

- la concertation avec et l'engagement des entreprises de recyclage et de production (y compris l'industrie chimique et les organismes de certification) dans le développement et la mise en place d'une politique CR.
- la bonne collaboration entre les différentes autorités impliquées (régionales, fédérales et européennes), p.ex. dans le cadre des offres publiques et des discussions éventuelles sur le CR dans l'écodesign, l'écolabeling, les véhicles « End-of-Life », la Directive sur les bonnes pratiques commerciales, le packaging.
- la définition claire du terme "contenu recyclé", des produits CR et des flux de matériaux qui sont ou doivent être pris en compte.
- la détermination des critères à être appliqués par les institutions de certification et les labos d'analyses lors de la certification CR des produits ou des entreprises de production ou de commercialisation des produits CR.
- la promotion du recyclage des matières premières et de la production de produits CR. Dans ce contexte, il est important de faire approuver au plus vite les critères EoW pour les produits recyclé au niveau européen ainsi que de trouver des solutions généralement acceptables pour le recyclage de produits aux SVHC. La promotion et le soutien de projets d'innovation axés sur le CR et de techniques "design for/from recycling" permet de catalyser l'ensemble, tout comme le suivi des défis.
- orienter les achats/appel d'offres publics vers des produits CR avec une performance identiques qui ne sont pas significativement plus chers que les produits analogues à base de matières vierges.

- implémentation et suivi de contrôle de marché.

En théorie, les principes du Contenu Recyclé peuvent être transférés aux autres groupes de matériaux (papier, métal, bois…). Cependant, la nature spécifique des matières synthétiques empêchent le transfert intégral tel quel des recommandations actuelles vers ces autres groupes.

Summary

Plastic recyclates and recycled content

Plastic recyclates are materials that can be applied in industry and that are made from internally or externally discarded polymer products (plastics, synthetic textiles, composites) that have entirely passed at least one mechanical recycling process. They can be processed together with identical or different virgin polymers by means of a melt process to create new products with a recycled content.

Plastic recyclates are subdivided in secondary raw materials for closed-loop (to manufacture the same product) or open-loop (to manufacture a different product) recycling. These neutral terms do not entail any judgement of the "quality" of the recycled application. An open-loop process does not automatically result in a devaluation of the material's value.

"Pre-consumer" and "post-consumer" recyclates are distinguished according to the fact whether they have been produced from products discarded by the consumer or not. Which recyclates the producer can include in his RC calculation can be determined by contract or by a Royal Decree. To offer sufficient growth opportunities to the circular economy it is proposed to include all possible recycling flows.

The "recycled content" (RC) of a new product can be described as the % weight fraction of the recyclates applied in this product (cfr. EN 14021). Both internal and external recycling flows can be included in the RC calculation.

To guarantee sufficient product stability, biodegradable and compostable recyclates are excluded, as well as recyclates made from oxydegradable polymer products.

Minimal requirements of RC products

It is impossible to assess the recycled content of a product by means of chemical analyses. The product and production data supplied by the producer in question are the only way to determine how much and which recyclates have effectively been applied in the production of an RC product.

To assure that buyers and consumers have enough trust in RC products, this information provided by the producer has to be correct and must be guaranteed time and again.

The legal framework regarding these RC products has to determine the "minimal requirements" these products have to comply with to be marketed as such.

The study team proposes the following:

- Guarantee a set minimum recycling content, calculated on the polymer fraction of the product (including additives and fillers). This content is either a minimum percentage, determined by the contracting authority based on the product type, or an open figure, but then rewarded proportionally. To obtain this content, all recycling flows may be applied. The indicated recycled content may however not be based on a single production run and has to rely on objectively determinable traceability and quality control systems at the producer's site, in conformity with EN 15343. The implementation and application of such management and control systems can be proved by a system certificate valid on the RC products in question that has been issued by a recognized certification organism.
- The RC product must comply with the applicable technical product specifications and other quality requirements and legal regulations. Product conformity shall be proven on the basis of internal quality controls or based on an external analysis report drafted by a recognized laboratory.
- The RC product may not be harmful to people's health or to the environment. In reality this means that the RC product is in conformity with REACH. Proving REACH conformity shall be based on valid declarations / certificates of the suppliers of raw materials or issued by a recognized laboratory.

In time, these minimal requirements will be completed with additional requirements (presence of nano-additives, rare metals or other functional additives). Moreover, in analogy with the periodic revision of standards, these minimal requirements will have to be revised every five years.

Certification systems in the context of RC product requirements

The success of RC products will largely depend on:

- Politics focused on the implementation of a circular economy model;
- The quality, availability and price of recyclates;
- Trustworthiness of the data on RC products used in this context.

The necessary data on RC products will always have to be supplied by the involved recycling and production companies.

To inspire sufficient confidence in this whole process, it has to be based on generally recognized certification systems with clear evaluation criteria. Both product certificates and company certificates can be considered. Of course, the certificates have to relate to the RC products in question. Accreditation (according to ISO 17021) of these certification organisms will inspire the necessary trust and create a level playing field in Europe. The supervision of possible abuse of certificates or logos on RC products has to be determined within the accreditation system.

Globally, a number of product and company certification systems verify certain aspects of RC products. Only 2 European certification systems (TUV and QA-CER) verify the three minimal requirements for RC products.

The importance of product analyses

It will never be possible to determine the recycled content (% weight) of polymer products by means of specific RC product analyses. However, the conformity of RC products with the other minimal requirements can be proven by means of concrete and trustworthy product controls and analyses.

Product conformity with the technical specifications as well as other quality requirements, such as REACH conformity, can be assessed by means of product/application specific quality controls and adequate chemical analyses by recognised and independent institutes.

Lacking the necessary equipment, many producers are unable to determine themselves these conformities. External product controls and chemical analyses have to solve this problem and ensure the necessary confidence.

By controlling and managing the different material flows (virgin polymers, recyclates, additives…) and by conducting different process controls, producers can of course limit the extent of external product controls and analyses, but they cannot exclude them.

Such product controls and analyses are not only important to the local production companies, but also necessary for importers of RC products that are being produced outside of Europe.

The implementation of goal oriented market controls is necessary to create a level playing field. Above all, these market controls have to relate to the validity of the certificates of the controlled RC products and on the REACH conformity of the RC products.

Problems and challenges related to a RC product policy

The success of a RC policy will be determined by different elements. The most important ones being:

- consultation with and engagement by the recycling and production companies (including chemical industry and certification organisations) in developing and implementing a RC policy.
- good collaboration between the different authorities that are concerned (regional, federal and European). For example in the framework of public tenders and possible discussions about eco-design, eco-labelling, End-of-Life vehicles, Good Commercial Practices Directive, Packaging.
- clear definition of the term "recycled content", RC products and material flows that may or must be included.
- determination of the criteria to be applied by certification institutes and test laboratories in the RC certification of products and of companies producing and/or marketing RC products.
- promotion of material recycling and the production of RC products. In this context, it is important to have the EoW criteria for recyclates as soon as possible on a European level as well as to find generally acceptable solutions for the recycling of products containing SVHC. The promotion and support of RC oriented innovation projects and "design for / from recycling" techniques can catalyse this whole process, as well as the follow-up of specific challenges.
- directing public purchases / tenders issued by the authorities on RC products with an identical performance and not significantly more expensive than analogous products on the basis of virgin material.
- implementation and follow-up of market controls

Theoretically, the principles of Recycled Content can be transferred to other material groups (paper, metal, wood…). However the specific nature of synthetic materials makes it impossible to transfer integrally the actual recommendations, without further ado, to these other groups.

This report draws on specific research carried out by Centexbel/VKC and UGent/CPMT on behalf of the FPS Public Health, in accordance with the agreements laid down in specifications nr.150007.

In the first section, this final report intends to present a number of market data and the general context with regards to polymer products and the associated waste problems and opportunities. In section two, consideration is given to recycling processes and plastic recyclates, as well as quality requirements and legislation. The third section defines the concept of "recycled content" and the material flows which can be taken into consideration to calculate the recyclate content in products. Section four highlights the various certification systems which are applicable to products with recycled content, or to companies which place such products on the market. The fifth section considers specific applications of the term "recycled content" by governments, as well as minimum criteria and a number of aspects which should be given sufficient attention. General conclusions will be made at the end of the report.

Notable data, attention points or important supplements are outlined to provide extra emphasis.

This report draws on an in-depth literature study (a summary of references used is in annex 1, bibliography), meetings with governments and various talks with recycling and production companies, as well as sectoral and European associations. Where appropriate, reference is made to supporting documents which can be consulted by clicking on the electronic report. In annexes 2 and 3, an overview of the used abbreviations and standards is provided.

1 Introduction and context

Economic and social development is impossible without a sustainable supply of raw materials. However, it is important to take into account the finiteness of these resources, and at the same time limit the current depletion of natural resources, due to the consequences for the environment and society.

The transition to an economy which promotes efficient use of resources implies tackling a number of significant challenges. Yet this is a necessary element for ensuring a high-quality environment and is an opportunity/challenge to strengthen the competitiveness of our companies, employment and the purchasing power of consumers.

The use of a higher content of recycled plastics in various products is an important step towards a sustainable supply of raw materials and the realisation of a circular economy. Plastic waste flows are still too easily incinerated too often, and in some cases are even landfilled. A wider dissemination of (well-known and reliable) labelling for the efficient use of recyclate would enable this market to grow, and consequently benefit the parties concerned (recycling companies, production companies and consumers) and help the environment.

Understanding and managing the recycled content in end products is not only useful information for both recycling companies and consumers, it is also necessary to create products in a controlled manner, which comply with the applicable requirements and/or other demands.

Recycled plastics are already used in a variety of products. Unfortunately, it is not entirely clear in which products we can find recyclate, and in what concentration. Some products bear a label which guarantees "recycled content". These labels are usually issued by certification bodies who develop their own audit system and test the company (or the product) based on this system. One major disadvantage is that few people are aware of exactly what these labels mean, and how

reliable and usable they are. It is also unclear how much recyclate a given product can, should or is able to contain in order for such claims to be made. These are just some of the reasons why these labels are not yet widely used.

A number of studies have already been conducted in this area, but the knowledge is highly diffuse and not generally understood.

2 General context with regards to the recycling of plastic products and the use of plastic recyclates

2.1 The importance of various plastics and plastic products

The efficient conversion of various plastic waste flows (plastic packaging, construction demolition, end-of-life synthetic textile, etc.) into raw materials and the use of recyclates in new plastic products must be placed in the broad environmental context of the last 50 years, in which the significance of various environmental effects and the responsible use of non-renewable raw materials and resources has very much increased.

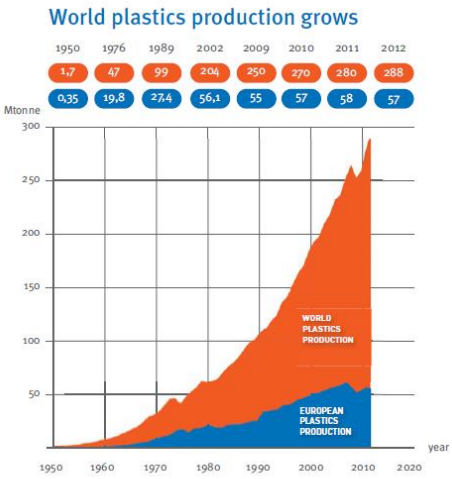
It started with a group of scientists (the Rome Club) who expressed their concern over the future of our planet and society in April 1968. In a period of full economic growth and increasing prosperity, they suggested that a number of natural and non-renewable resources would one day be used up and that our survival would be determined to a large extent by our ability to effectively tackle the environmental problems which are unique to our modern society.

But the 1960s were also progressive years during which many new polymers were developed and improved. Due to their easy ductility, light weight, corrosion-free properties, etc., plastics, synthetic fibres, polymer coatings, etc., all replaced various traditional raw materials (metals, ceramics, natural fibres, etc.) in many products and applications.

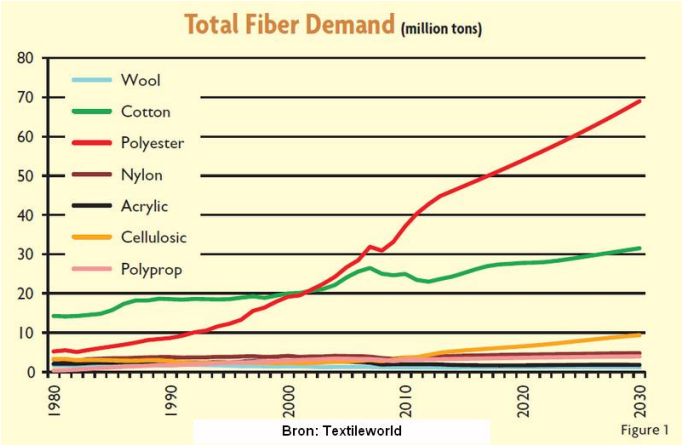
In particular, the relatively low cost of virgin polymers and their countless beneficial properties have led to an enormous increase in polymer use in recent decades.

The low sales prices of virgin polymers and the possibility of polymer degrading in the event of multiple (re)processing explain why plastic recycling was only given attention so late, and why it is still so limited.

Polymers used in the production of plastics and textile have not only contributed to economic growth (see graphs below) but also to the creation of a "throwaway society", catalysed by ever-growing environmental problems.



Bron: PlasticsEurope (PEMRG)

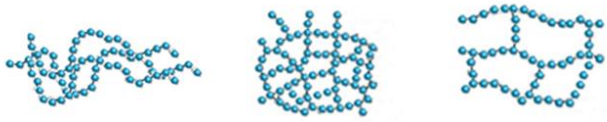


Bron: Textileworld

Figure 1

Globally, around 310 million tonnes of polymers are placed on the market every year, including +/- 20% in Europe, for the production of plastics, textile fibres and yarns, composites and coatings, which in turn are processed into a large number of products.

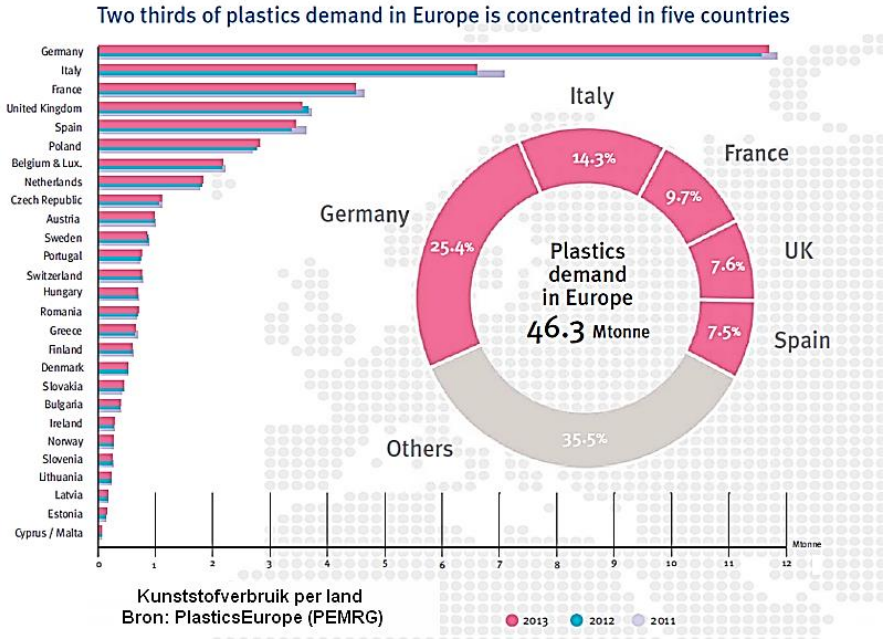
There are many different polymers, each with their own properties. On the basis of the physical (mechanical and thermal) properties of the polymers, a distinction can be made between thermoplastics, thermosets (resins) and elastomers.



Thermoplasten Thermoharders Elastomeren

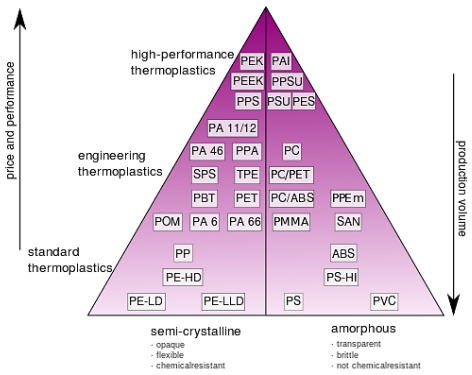
- Thermoplastics, the most important group of polymers, are solid materials which plastically deform when heated, and usually have a melting point. They become solid again on cooling. The polymer chains are not linked to each other and can move independently. This reversible character (solid <> liquid) explains their use in "melting" treatment processes. Thermoplastic polymers are processed into plastics and synthetic textile fibres.
- Thermosets are thermally curable (or UV curable) polymers (resins) whereby the chains cross-link. When the cured material is heating, thermoplastic forming is no longer possible.
- Elastomers are elastic materials which return to their original form after being deformed. The specific elasticity is obtained by specific bridge connections between polymer chains. Rubbers are natural elastomers which only obtain their elastic properties after a partial cross-linking (vulcanisation) of the polymer chains.

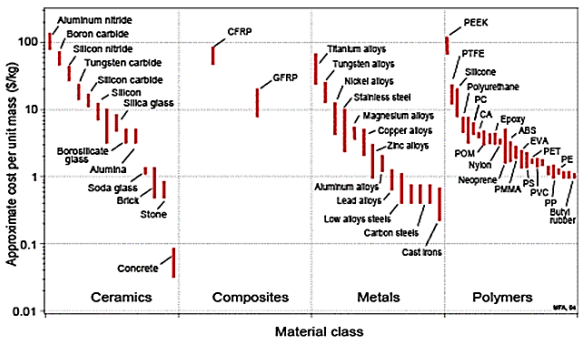
Two thirds of European plastics are consumed (processed) in the 5 largest European countries, according to PlasticsEurope. With a market share of 4.3%, Belgium is the 7th largest processor (consumer) of polymers. Belgium produces 10% of the polymers produced in Europe.



Most plastics are produced and consumed locally (close to the most important buyers). Due to their light weight and large volume, the transport costs for many plastics are high, meaning that faraway production (e.g. in Asia) is pretty much ruled out. In addition, the most significant costs for European plastics processors consist mainly of material and energy costs (together representing more than 85% of the total product cost) and less from labour costs, which is beneficial for the local or regional production of plastics. The high material and energy costs are important triggers for the use of recyclate.

Depending on their performance, price and quantities, thermoplastic polymers can be further divided into various categories (commodity plastics, engineering plastics and speciality polymers).





The cost price of "virgin" polymers, which represent more than 85% of all thermoplastics, currently fluctuates between 0.8 and 2 euro/kg.
The virgin polymers, which are > 99% based on oil or gas and produced by major chemical corporations, are materials for which the prices are determined at the international level. Due

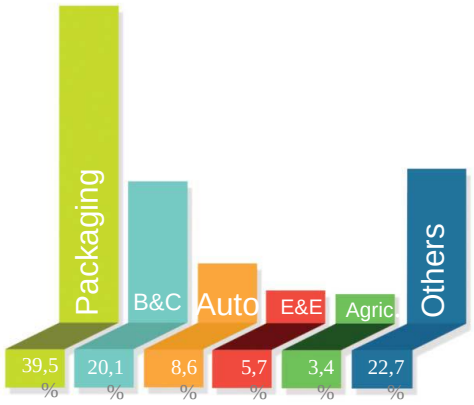
to the low prices of the oil and gas from which they are produced, and the large scale and performance of the chemical installations where they are made, the prices of polymers are low.

The low sales prices of virgin polymers make the efficient recycling of polymer products difficult. Virgin plastics have consistent quality. They do not contain impurities, which cannot always be said for recyclates. In order to guarantee the quality of many recycled polymers, or to keep it consistent, it will be mixed with virgin polymers. This addition of virgin polymers is not necessarily done to comply with waste legislation. In addition, this mixing ensures that the concentration of non-REACH-compliant additives, originating from recycled products, is sufficiently low, whereby they still comply with the REACH legislation.

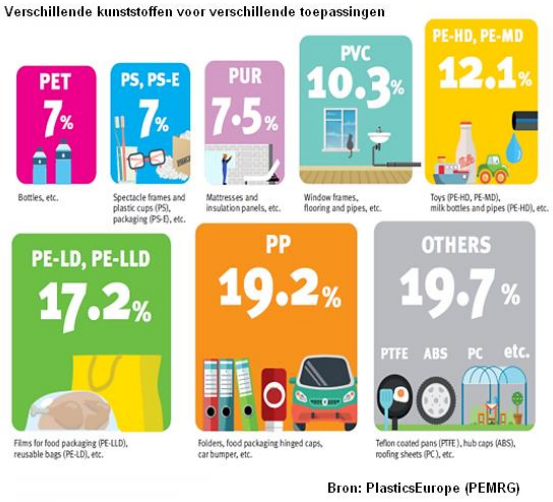
Notwithstanding the huge range of different polymers, the European plastics market is dominated, for almost 75% (in tonnes), by just 5 thermoplastic polymers, namely polyethylene (PE), polypropylene (PP), polyester from polyethylene terephthalate (PET), polyvinyl chloride (PVC) and polystyrene (PS).
The proportionately high share of these "commodity" polymers is determined by their specific performance and properties in large areas of application such as packaging and various construction products. Advanced and special polymers are applied in specific areas (the aviation industry, vehicle components, skylights, gears, etc.) where high technical and safety demands prevail.

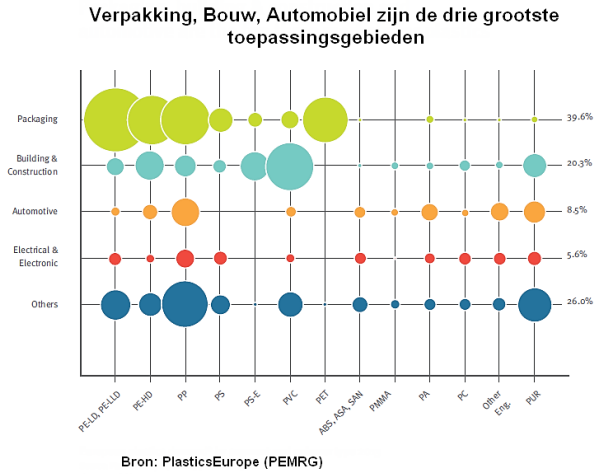
The most important areas of application of thermoplastic polymers are:
- packaging: plastic film, drinks packaging, trays, etc.,
- construction products: pipes, window profiles, roll-down shutters, insulation, flooring, etc.,
- transport: vehicle components and interiors, etc.
- textile: clothing, curtains, seat cushions, carpets, technical applications, etc.
- WEEE: cables, TV, computers, household appliances, etc.,
- agriculture: film, agrotextiles, plant pots, etc.,
- other: toys, furniture, etc.

Packaging is the largest consumer of plastics.



According to PlasticsEurope, the European market share of various polymers in a number of areas of application in 2014 was reflected in the figures below.





Please note, this breakdown is "plastics"-specific. When we take into account the same polymers, which can also be used for the production of synthetic textile fibres, yarns and nonwovens, then the proportion of PET (clothing, interiors and technical textiles), PA (carpet) and PP (carpet, agrotextile, hygiene-nonwovens) is much bigger.
PVC is not only used in rigid plastics, but is an important coating polymer (at least in weight) for various textile products (PVC-coated textile is used inter alia in tarpaulins for trucks, inflatable structures, sun blinds, wallpaper, boots, protective clothing, gloves, etc.) whereby the proportion of PVC within Europe is also larger than what is indicated in the graph of PlasticsEurope.

The various end products are rarely comprised of just polymers. Moreover, for every polymer there are various types and grades with specific properties or melting behaviour. Many plastic products are made of "plastic formulations" whereby the polymer proportion is usually 50%, although sometimes less. The low density of polymers in relation to mineral fillers or other additives explains why the actual "polymer" content in plastic products containing a lot of fillers or reinforcement fibres may be relatively low.

By adding fillers, reinforcement fibres, pigments and/or other (functional) additives, it is possible to improve the mechanical, electrical, (bio)chemical or other properties, and extend the field of application.

These days, there are practically no longer any areas of application where plastics do not play an essential role in meeting pre-established demands with regards to comfort, energy consumption, etc.

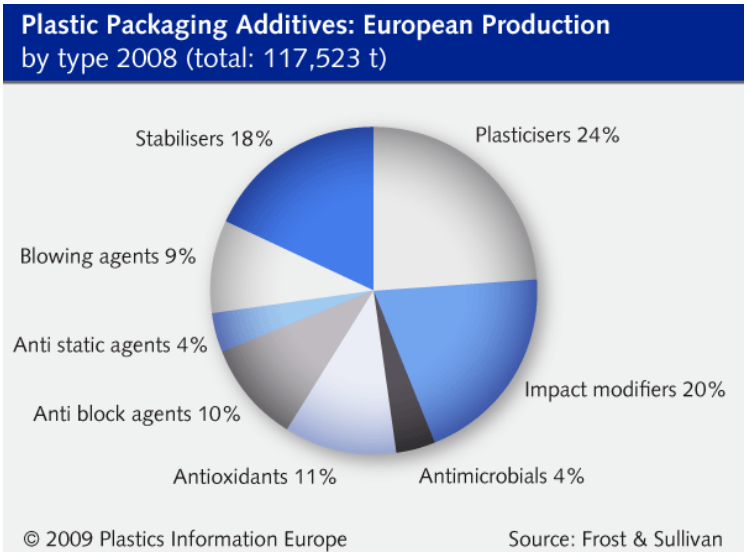
Worldwide, the amount of additives (pigments, fillers, reinforcement materials, plasticisers, functional additives, etc.) for plastics is estimated at +/- 10% of total polymer production. In many plastic products, the concentration of such substances is relatively low, although in some products it can be more than 60%. Many additives are chemical substances which must comply with the REACH legislation (this will be explained in more detail later).

These additives are included in the polymer matrix and form, along with the polymer mass, a fairly homogeneous material (plastic) from where they will not migrate in principle (with the exception of certain plasticisers) and cannot be washed away (leached).

By means of mechanical recycling (see below) these additives are not released and remain encased in the polymer matrix.

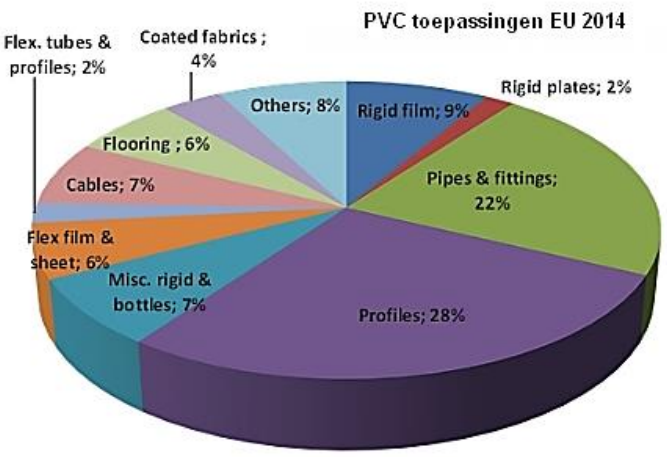
Certain additives which used to be frequently applied in polymers (plastics, textile, etc.) should be considered as "SVHC" - Substances of Very High Concern - which cannot be used, or only under certain conditions, or be present in certain products.
In principle, this also applies for recyclates, which should be considered as valuable but composite raw materials. The composition of the plastic recyclates is identical to that of the plastic products from which they are made via mechanical processes.
By compounding, (see below) the composition of recyclates can be adjusted.

The figure below indicates the market share in 2013 (Smithers Pira) of the most common "functional" additives, which are currently used in a large amount of plastic packaging. The very large share of oxygen scavengers is explained by the large-scale use of these specific additives in plastic packaging for food, drink, medicines and personal care products. By adding such additives, the shelf life of packaged products can be significantly extended, which justifies the additional cost of the functionalised packaging.



The enormous diversity of exact product composition, and the fact that this composition of post-consumer waste is not entirely known, can hamper economic recycling.

The figure below shows, as an example, various PVC products which are produced on the basis of different PVC formulations (source www.pvc.org). Not only can different PVC plastic types/grades be used, but there can also be an enormous discrepancy in the quantities and types of additives (stabilisers, fillers, plasticisers (in soft PVC), fire retardants, etc.), in the formulation.



Bron: www.pvc.org

The large diversity within formulations means that not all collected end-of-life products made of the same polymer type can be used to the make the same recyclates. There are no universally-applicable recyclates. The economic and technological added value of the multiple additives present in recyclates is not recognised. Unfortunately, the value of recyclate is only determined by the polymer content.

2.2 Plastic waste and plastic recycling

Both during the production, assembly and installation of materials/products, and at the end-of-life of products or constructions (EOL), a lot of plastic waste is created which can be (selectively) collected, or which falls under the residual waste fraction (which is then usually incinerated or landfilled). A portion of this waste disappears in an uncontrolled manner as litter, plastic soup, etc., in nature (on land, at sea).

Due to its huge quantities, bulky character, and long decomposition time, polymer waste has become a major societal problem in recent decades. Plastic products are used everywhere, on a large scale. The consumption of plastic packaging materials continues to grow faster than that of other materials (glass, metal, etc.). Additionally, many plastic products only have a short life (most packaging materials are consumed within 3 months).
Unfortunately, polymer products are only recycled to a limited extent, either as a material or as an energy source.

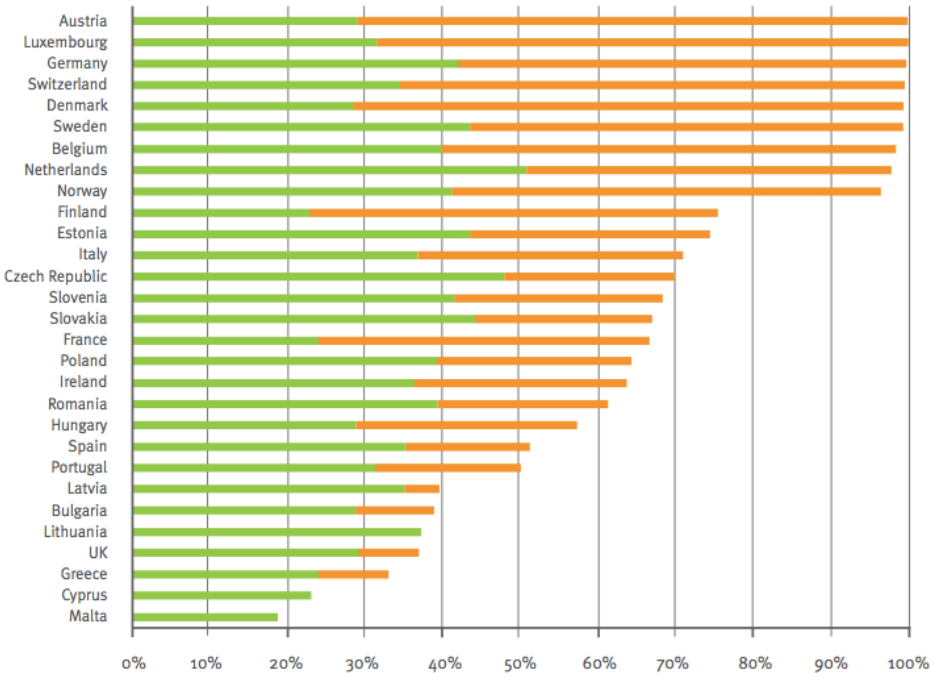
In 2012, 25 million tonnes of post-consumer plastic waste was collected in Europe, which equates to roughly 50% of the amount of plastic produced every year.

PET drinks packaging, LDPE packaging film, HDPE bottles and PVC construction products are the most important post-consumer waste flows which are currently selectively collected and partially converted into recyclates in most European countries. There are well-functioning value and supply chains for these recyclates. Other plastic products, which are composed differently, or in a more complex manner, or which are contaminated, usually end up in bulky waste, or the residual waste fraction, which is usually incinerated (with or without energy recovery). For these materials, there are currently few or no operational recycling and valorisation chains.

Of the European plastic waste which was selectively collected, +/- 26% was recycled as material (mechanical recycling), 36% was used for the production of energy (thermal recycling) and 38% was landfilled, although there are considerable differences between the various countries.

The proportion of feedstock or chemical recycling of plastic waste is currently almost negligible. The possible implementation of very large gasification plants for plastic waste, for the production of basic chemical substances, can very severely restrict the mechanical recycling of polymer products and make it unviable.

The graph below shows the European situation in 2012, whereby material recycling (green) and energy production (orange) are indicated.



Packaging recycling and energy recovery rate by country 2012
(Referred to post-consumer plastics waste)
Source: Consultic

It is pretty much only thermoplastic products made from one polymer which are actually converted into recyclates.

Only 15% of EOL rubber products (especially vehicle tyres) are recycled as material. 60% is converted to energy and the rest is landfilled.
Less than 10% of thermosets and fibre-reinforced composites are recycled into material which can be used as a raw material or filler for thermoplastics, bitumen, coatings or sealants.
Glass fibre-reinforced plastic waste can be processed in the cement industry, but due to its low value, is also almost always landfilled. Carbon fibre-reinforced composites are an exception in this respect. Recovered carbon fibres from the aviation industry are interesting reinforcement fibres for technical thermoplastics (among others, PA).

2.3 Recycling of polymer products in Belgium

In Belgium, +/- 29% of post-consumer polymer waste is selectively collected and/or recycled into raw materials. This is high in comparison with many other European countries.
The recovery & recycling activities of the 45 environmental and recycling businesses established in Belgium can be broken down as follows (according to the JRC-IPTS report EoW-criteria p. 71 on the basis of Plarebel data)

Number of companies	Sorting & conditioning	Grinding & reducing	granulating & compounding	end products
4	X			
9				X
1			X	
8		X		
5	X	X		
14		X	X	
4		X		X

Only 19 environmental companies have more than 2 recycling processes (production of end products is not considered as a recycling process), 31 recycling companies can reduce plastic waste, including 5 companies which do this to material they have sorted themselves, 15 companies re-melt or compound plastic waste, and 13 environmental companies produce RC products.
Important Note: The 45 Belgian companies are companies which "claim" to be environmental or recycling companies via Plarebel, an NGO focused on the recycling of plastics, and the FOST PLUS expertise centre (http://www.epro-plasticsrecycling.org/companies/17).

The conversion of post-consumer waste, collected in Belgium and recovered by sorting, into recyclates unfortunately mainly takes place in our neighbouring countries (D, NL and F) or in the countries to where these plastics recovered for recycling are exported (both within and outside Europe).
We can more or less state that Belgium is a pioneer in the selective collection and sorting of waste, but that the recycling (converting products into usable material) of the sorted materials predominantly occurs abroad.

In contrast with the limited number of environmental & recycling companies which recycle plastics for local industry or for export, there are numerous producers (plastics processors and textile companies) which actually recycle their internal waste flows (post-production or pre-consumer waste) and re-use it in RC products.

There are few if any reliable data regarding pre-consumer (also called 'post-production') waste quantities. Such waste/loss material, for which the composition is very well known and always REACH-compliant, does not need to be registered as such (or communicated to external organisations). The producers who recycle themselves usually do not consider this material as waste.

A targeted survey by Centexbel/VKC of various Belgian production companies shows that post-production waste/loss very rarely amounts to more than 5% of the total production, and that more than 90% of such material (after internal or external recycling) is used again as raw material, either by themselves or by third parties.
Material costs, the largest cost item for production companies, is the main trigger to avoid material loss and use their waste/loss again (preferably as quickly as possible) in production processes. The percentage of loss or internal waste figures are small but nonetheless represent an amount, for Belgium, which can be estimated at at least 120,000 tonnes of polymer material. Of this, 90% can be used in new products.

The use of plastic recyclates is very well assimilated in some (sub)sectors such as textiles.

- Pretty much all Belgian textile companies have replaced conventional virgin polyester yarns or fibres with recycled PET fibres.
- All new PVC flooring materials (PVC tiles) which were predominantly produced by several major Belgian companies (Unilin, Beaulieu) are based on recycled PVC material.
- All the major Belgian carpet companies (Balta, BIG, Desso, Lano, etc.), representing more than 50% of European production, have developed synthetic carpet qualities based on recycled PA yarns, as well as carpets for which all the components are constructed with the same polymer, which facilitates recycling.

2.4 Survey of companies and associations regarding the use of post-consumer recyclates.

The relatively small European recycling score (< 26%) for collected polymer waste and the use of recyclates was discussed with the sectoral associations and a number of recycling and production companies, as part of our research.

The reasons they gave for the limited recycling into material and limited <u>use of post-consumer recyclates in production</u> are listed below:

- the large diversity of "formulated" polymer products. Even if the waste flows are made up of identical polymers, they cannot always be processed together. The clustering of certain waste flows only occurs for a limited number of waste flows. Plastics recycling usually occurs in batches, and the batches are usually too small to be used in mass production.
- The fact that a lot of plastic waste flows are coloured. This means that they can only be used in products where the colour is not important, or in interlayers which are not seen. There are currently also no economically viable decolouring techniques to solve this problem.
- the operational selective collection systems are currently limited to a number of products such as PMD, industrial packaging, etc. (PET, HDPE, PVC, EPS) which can be sorted both visually and via automatic detection systems.
- the contaminants present in post-consumer waste flows (dirt, non-compatible polymers, biodegradable polymers, metals, glass, etc.) hinder its processing into new products.
- the high transport costs (combined with the low density of the collected plastics), bulky products cannot be compressed, or hardly at all. By compacting waste flows, the sorting process is impaired.
- the fact that many high-quality polymers are (too) cheap, meaning that the price difference between virgin polymers and recyclates is relatively small. If the prices of virgin polymers become extremely low (e.g. due to cheap oil or shale gas) the production of high-quality recyclates becomes unjustifiable.

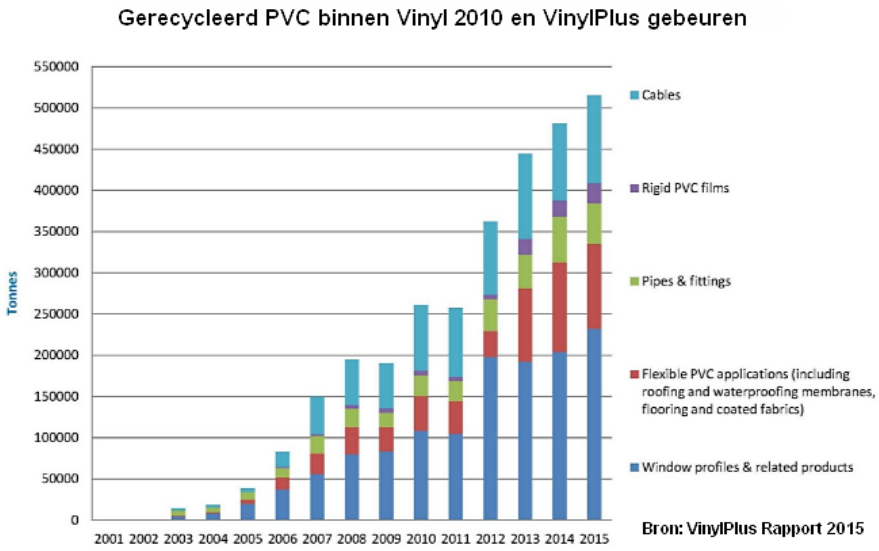
- the limited availability of large quantities of high-quality recyclates with the desired composition. The very large diversity in terms of the composition of EOL products and the possible presence of contaminants explains the limited supply of "high-quality recyclates" in large quantities. Both quality and quantity can only be guaranteed for a limited number of recyclates (including R-PET).
- the low costs of incinerating or landfilling waste, compared to the higher costs for material recycling. In certain cases, a trade-off can be found between a product's level of recyclability and other objectives, such as energy efficiency. The extremely large incineration capacity created by inter-municipal associations and environmental companies in recent years hampers material recycling.
- the lack of an international level playing field for recycling. The market for waste is an international market. Waste is often transported to countries where it can be processed as cheaply as possible. From an environmental perspective, this is not necessarily a problem to the extent that the recycling process in these countries also fulfils the minimum conditions with regards to the environment, health and safety of citizens and employees, etc. This is not always the case, especially in developing countries.
- uncertainties regarding the possible presence of SVHC components in certain waste flows (REACH compliance - see below).
- too little or no application of eco-design techniques (Design From/For Recycling) by production companies for the development of new polymer products meaning that not many products can easily be dismantled or recycled.
- the lack of reliable data regarding the processing of recyclates in industrial production lines. Currently, the producers of recyclates also do not provide the same technical support to production companies as the producers of virgin polymers to resolve production problems, product complaints, etc.
- the limited cooperation and networking between recycling companies and local plastics processors, composite producers and textile production companies. Many recycling companies focus on export, and too little on local production companies.
- non-desirable consumer behaviour with regards to waste: plastic waste is seen by many consumers as "worthless" material, meaning that a lot of packaging material is discarded or thrown away by certain consumers/tourists. A lack of discipline on the part of people is also the main cause of maritime plastic waste.
- the too limited knowledge regarding polymers, additives, formulations, recyclates, polymer products, the applications of polymer products, etc., among both recycling and production companies.
- the (current) lack of initiatives regarding specific plastic end products in the context of "extended producer responsibility" (EPR), which is supported by all parties concerned. Due to the generally negative market value of polymer EOL products, the costs for their selective collection, or the introduction of compulsory take-back obligations for these products, are relatively high, which hampers the implementation of specific initiatives.
- the current lack of clear EoW (End of Waste) criteria and minimum quality requirements for recyclates (see below).
- the (current) lack of clear objectives with regards to recycling at the level of companies, sectors and regions.

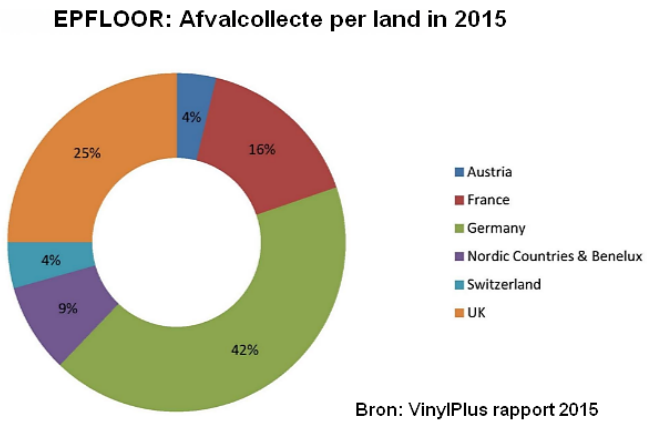
The importance of clear recycling objectives is illustrated, using the graph below, by the successful recycling of PVC products.

- In the 1980s, PVC and the incineration of PVC was put under intense scrutiny. Corrosion from waste incineration facilities and the release of dioxins when PVC was burned prompted a

number of major PVC producers (including Solvay) and various European plastic processors to launch Vinyl 2010 and set clear recycling objectives.

- In the context of Vinyl+ (the successor of Vinyl 2010), the aim is to collect and recycle 800,000 tonnes of PVC products by 2020. To achieve these objectives, subsystems including EPFLOOR were also set up for the collection of soft PVC flooring.
- These voluntarily established systems have motivated a sufficient number of producers to take part. If the system had not been so effective and efficient, the importance of PVC products and PVC recyclates within Europe would be much smaller.
- Due to these objectives, there is currently sufficient PVC material on the market on which the development of new RC products can be based.





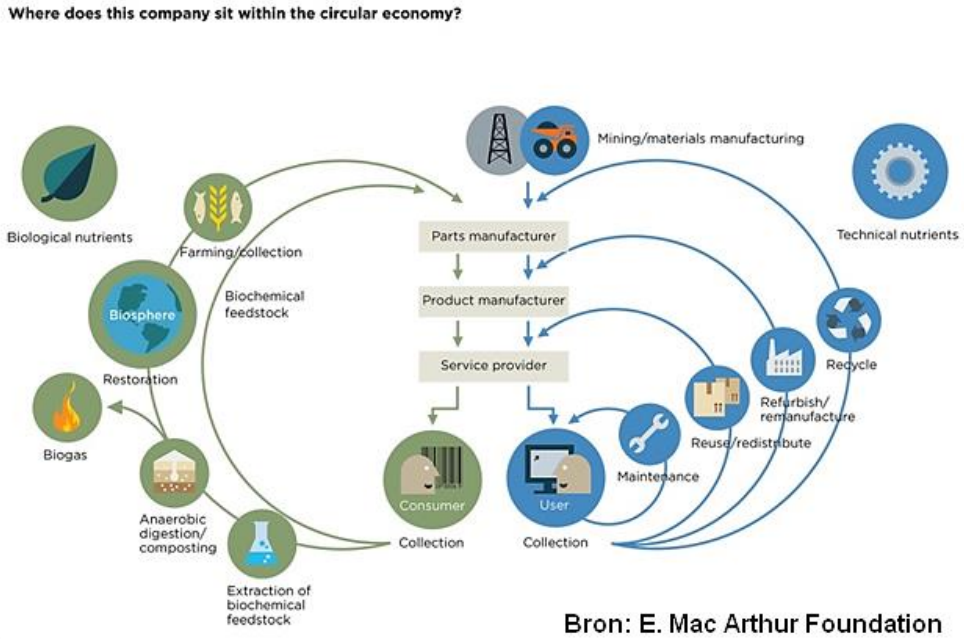
2.5 Importance of the circular economy

The conversion of very bulky waste flows of plastic and other polymer products (synthetic textile, composites, rubbers, etc.) into recyclates for (local) production companies, as well as the prevention of specific problems such as marine litter and micro plastics are important challenges within our society.

The problem of waste from plastics and the need to find a solution are brought into sharp focus in the document "The new plastic economy – Rethinking the future of plastics".
This document (http://www3.weforum.org/docs/WEF_The_New_Plastics_Economy.pdf), published by the Ellen MacArthur Foundation and presented at the annual World Economic Forum 2016, is a working document for the relevant professional federations and research institutions to further develop specific actions.

If we manage to recover more plastics and efficiently use them as raw materials, we will be able to limit our major dependence on oil and other natural resources, and reduce emissions of CO_2 and particulates (from incineration).
Not only will this make European industry more sustainable, it will also revitalise it. By recycling various waste flows, environmental companies will eventually become important and reliable raw materials suppliers for production companies, like the current producers of virgin plastics.

In addition, the introduction and application of a circular economic model should help.



Bron: E. Mac Arthur Foundation

In the **circular economy**, presented in the diagram above (ref. E. Mac Arthur Foundation), a distinction is made between four types of economic activities which are also referred to as "loops": (a) the loop for maintenance and repair, (b) the loop for reuse, (c) the loop for the refurbishing and reproducing of articles and (d) the recycling loop. A major economic impact is predicted for the "recycling loop" in particular.
It is important that loops remain local as much as possible so that unnecessary transport and related CO_2 emissions are avoided. This would also encourage local employment. The fact remains that economies of scale are important for some loops, whereby the access to, and therefore the import of, raw materials is crucial. The current recycling techniques are mainly based on bulk-related (tonnes) activities.

By implementing the circular economy, which will take many years, it is expected above all, besides resolving the social problems associated with waste, that added value will be created for local businesses as well as profitable recycling companies, ensuring the creation of new and high-quality jobs.

In February 2016, the Central Economic Council (CEC) issued the CEC 2016-0496 recommendations (http://www.ccecrb.fgov.be/txt/nl/doc16-496.pdf) with regards to the circular economy with a focus on recycling, in which they:

- refer to the need for a coherent long-term government policy (10 - 20 year vision),
- raise awareness for the entire recycling value chain
- reiterate the importance of training and social dialogue.

In this recent recommendation, reference is made to the joint publication by the FPS Economy and the FPS Public Health "Belgium as a pioneer of the Circular economy", and to the report (doc. 14-998) "General principles for a policy to stimulate recycling" by the "Resource efficiency" platform.

- Not only does the joint FPS publication lay down the vision for the circular economy, but also a number of objectives. A number of proposals should help to quantify the objectives and measure their progress, contribute to the introduction of new innovative and effective business models, provide information to the relevant actors and influence the European debate on the subject.
- The general stimulation principles for recycling proposed by the "Resource Efficiency" platform are based around 4 areas, namely:
    - the design of products: eco-design, "design for & from recycling", LCA (Life Cycle Assessment) studies, EoW criteria for recyclates, standards and specifications for recycled materials, cooperation/networking between recycling and production companies, etc.
    - availability of (sub)products/waste which can be converted into recyclates. In many cases, the economies of scale of the environmental companies which only collect and sort locally are insufficiently large, meaning that the import of suitable waste flows needs to be facilitated, etc.
    - recycling processes: creating a stable legal framework, stimulating innovation, assessing regulatory hurdles, incorporating the social economy, etc.
    - placing recycled materials on the market or products with recycled content: evaluate and possibly eliminate regulatory hurdles concerning recyclates and products with recycled content, green public procurement, etc.

The transition from a linear to a circular economy will not be so straightforward and will require great efforts on the part of all the actors concerned (production companies, consumers, governments, suppliers, service providers, etc.) preferably in the context of a stable, coherent and coordinated policy that takes into account the numerous policy competence that is divided between the Belgian (regional and federal), European, and international level, and with the many existing initiatives on the part of the governments concerned.

A very recent development is the growing interest in recyclates among producers of virgin polymers (including Total, Borealis, Dow, etc.). They take over specialist recycling companies, or purchase specific post-consumer recyclates from certified recycling companies. They process this produced or acquired recyclate together with special virgin plastics developed by themselves (re-boosting plastics) to create compounds that are the same or sometimes of better quality than their conventional virgin plastics which are used by plastics processors. Certain compounds, developed as part of the circular economy, can contain up to 70% recycled post-consumer polymer. They have the specific recycled content of their compounds certified by an independent organisation.

This new approach can ensure both product quality and supply reliability for plastics processors, which the majority of recycling companies cannot guarantee by themselves. Thanks to their in-depth product and market knowledge of the producers of virgin plastics, they can provide "RC compounds" which can be used without any problems by plastic processors. This is not currently possible for all plastics and plastic grades, but this is the avenue they wish to explore further.

Closing as many diverse material loops as possible should be given more priority in our economic system. Not only does this need to occur for the easiest waste flows, but also for the contaminated and complex composed products which require other recycling processes. Various sticking points, including the REACH compliance of recyclates (see below), also need to have pragmatic solutions.

It would be naive to think that the recycling possibilities are sufficiently effective and efficient to tackle major societal challenges such as waste, climate change, health, etc., by themselves. It needs to be examined whether the strong emphasis on recycling does not hinder the prevention of waste or the immediate re-use of end-of-life products or objects. In establishing a circular economy, there needs to be continual focus on prevention and encouraging environmentally sound consumption patterns.

3 Plastic recycling and recyclates

3.1 Recovering recyclable materials and converting these materials into recyclates

"Recyclate" is a "waste" and "raw materials" -related concept that must be framed within the general context of a sustainable society, in which waste is seen as an important problem, both economically, ecologically and socially, and which therefore needs to be prevented or minimised.

Waste refers to "substances, materials and products which the owner wants to get rid of". The owner may be a consumer or a company, an organisation (e.g. Fost Plus) or a government. A waste collector can also be or become a waste owner.

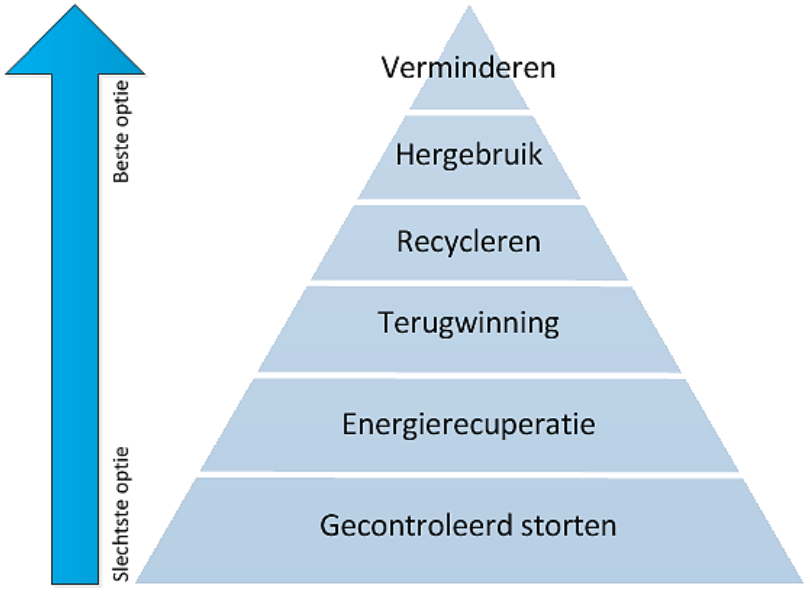
Waste flows which are harmful for humans, animals or the environment must be considered as **hazardous waste**. In principle, this waste is not recycled into raw materials. Empty plastic packaging in which hazardous substances such as biocides, medicines, sprays, etc., were packaged, are also usually regarded as hazardous waste, and this kind of packaging material may contain residues of harmful substances which are not so easy to remove. Medical waste which can contain significant quantities of plastic (syringes, blood bags, catheters, etc.) is also regarded as hazardous waste.
This waste is currently incinerated in approved facilities. However, one could ask the question whether some of these waste flows, of course with appropriate detoxification techniques and the application of strict procedures, are perhaps suitable for creating plastic recyclates.

Following the REACH and CLP legislation (see below), a growing number of plastics are labelled as hazardous waste, due to the presence of certain harmful additives. The Dutch National Institute for Public Health and the Environment (www.rivm.nl/en) wants to open this problem for discussion, and has recently published the RIVM Letter Report 2016-0025 "Plastics that contain hazardous substances: recycle or incinerate?". A number of conclusions or proposals from this report will be discussed further.

The European Waste Framework Directive 2008/98/EU describes "**recycling**" as any recovery operation by which waste materials are reprocessed into recyclates (the raw material for producing polymer products), chemical substances, fuel or energy.

Within this framework directive, a focus on the appropriate **"waste hierarchy"** (prevention > re-use > recycling and use of materials in closed-loop material cycles > energy recovery > disposal) and **Extended Producer Responsibility** (EPR) can form the basis for developing robust policy instruments.

- Within the waste hierarchy, conversion into materials (recyclates and chemical substances) takes priority over the incineration (with energy recovery) of waste. However, in practice, more plastic waste is incinerated than converted to raw materials. Nonetheless, plastic waste is a cheap, energy-rich fuel for energy generation. By obtaining more and more plastic products for material recycling from the bulky waste and residual waste which is currently collected, the energy content of the waste that is incinerated can be reduced.
- The Green Paper of the European Commission regarding the European strategy for plastic waste in the environment (http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52013DC0123) refers to the importance of respecting the waste hierarchy.



- The Extended Producer Responsibility (EPR) for products can bring about the establishment of take-back systems for EOL products, whereby the amounts of waste to be converted to materials may increase.
    - Producers of goods are (financially) responsible for the collection and recycling of post-consumer waste. In most cases, this will result in the establishment of a collective 'producer responsibility organisation', where producers unite to limit the administrative burden. The associated costs are usually incorporated into the prices of new goods. As a result, the waste processing is passed on to the consumer (the 'polluter pays' principle) but due to international competition, this price increase is not always possible, which of course has an effect on the operating results of local producers who have to contend with EPR costs.
    - EPR is an instrument which is currently applicable for a limited number of products (including batteries, vehicles, WEEE, packaging material, solar panels, etc.).
    - For complex composite products such as vehicles and electronic goods, it is possible to achieve the predetermined recycling targets, but definitely not for the plastics contained within them. The very low residual value and the bulky nature of plastics, as well as the possible presence of SVHC in plastics explains why "material" recovery and recycling is focused mainly on the presence of ferrous and non-ferrous materials. The chance of finding SVHCs in recyclates from vehicles or electrical goods is much greater than for other plastics. Many plastics in these specific areas of application contain brominated fire retardants.
    - Putting "weight" -related objectives as a priority for bulky products with relatively low economic value (such as the majority of polymer products) will always be difficult. Recycling and the use of recyclates remains a matter of economics.
    - Applying EPR at the regional level could potentially distort the market. Indeed, the European market is an open market in which both production and recycling companies can readily move to regions where EPR does not apply. There is a danger that local EPR-regulated products lose market share to cheaper alternatives from countries where no EPR applies.

- Applying EPR to a specific product and not on all similar products may also have a distorting effect on the market. For example, by only applying EPR to carpets, other floor coverings (vinyl, laminate, etc.) will be promoted and cross-border purchases will be stimulated.
- EPR is an instrument that still needs to be developed for most products, in consultation with the parties directly involved and preferably at the European level.

For certain products, EPR could be linked to other policy instruments such as recycled content (see below), recycling certificates, innovation support, etc., but the possible effects of such links are unknown and require additional research and consultation with the parties concerned.

The term "secondary raw materials" which was used in the previous Waste Directive of 2006 has been scrapped in the new framework directive. In its place, a turning point is used whereby waste receives the designation **"End Of Waste"**, and is consequently no longer waste.

EOL products (packaging, end-of-life household appliances, vehicles, etc.) or parts of these which can be separated through selective collection and/or products/materials from certain isolated waste streams (sorting, separation, split-off, removal) for further recycling, are regarded as **"recovered material"**

The most important recovery processes can be presented schematically as follows:

Input	Option	Process	Output
EOL/EOW		Collection and preparation	Process input for reuse, material or energy recovery
	Material recovery	Mechanical recycling (primary and secondary recycling)	Recyclate or (half) finished products
		Feedstock or chemical recycling (tertiary recycling)	Chemical substances (monomers or oligomers, or other substances/reaction mixtures (gas, liquid or solid)
		Biological or organic recycling	Compost/methane
	Energy recovery	Direct or controlled incineration (quaternary recycling)	Heat, steam or electricity

Mechanical recycling, whereby "recovered materials" is converted to **"recycled raw materials"** or **"recyclates"**, is by far the most widely used recycling technology for polymer products.
In contrast to chemical recycling, the polymer structure is basically undegraded during mechanical recycling.
Using mechanical recycling, the energy content of polymers (the energy required to produce polymer from oil or natural gas) can almost be completely recovered.

When mechanically recycling EOL or EOW products, the entire product composition of these products (usually consisting of 'formulated polymer') remains intact. The additives which are present in the polymer matrix of the products will not be released in principle, and will also remain present in the recyclates.

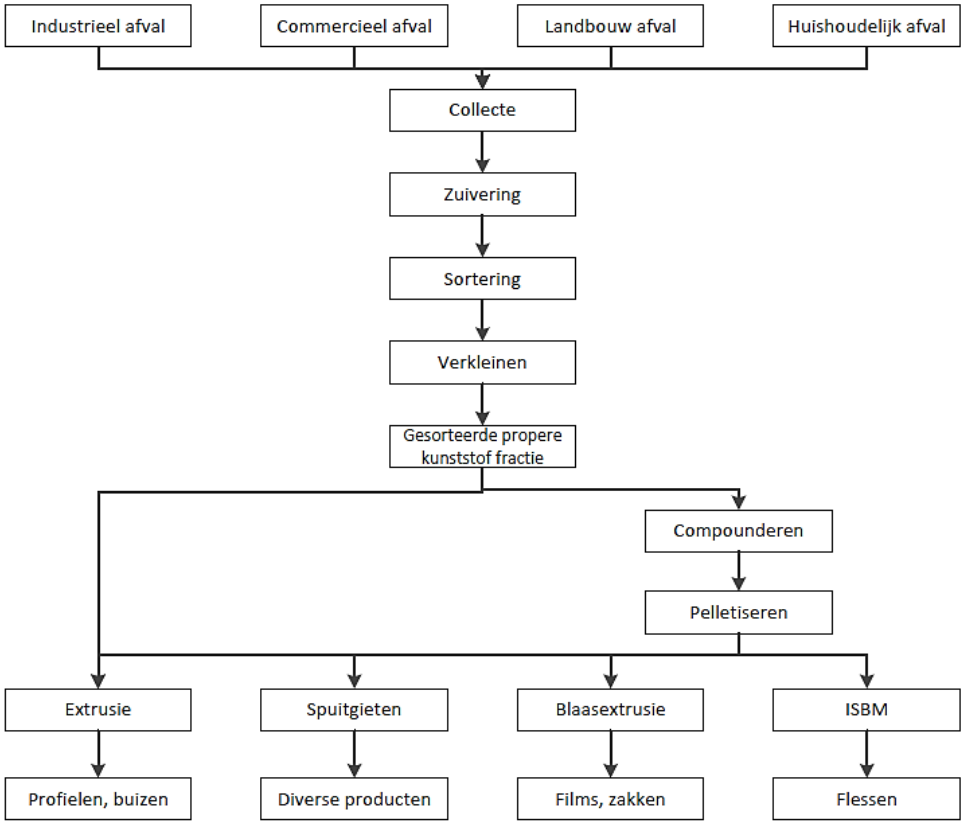
By means of specific extraction techniques and chemical purification techniques, certain additives (e.g. pigments, plasticisers, etc.) can be removed.

Because most plastic products contain additives (such as fillers, functional and other additives), recyclates from a given plastic never have the same composition as the homologous virgin polymers which they will completely or partially replace. Additives which are (or were) widely used in plastics to obtain certain characteristics (stability, softness, fire resistance, hydrophobia, etc.) are chemical substances which have become SVHCs under the REACH legislation. Recycling older products containing SVHCs also means that the recyclates also contain SVHCs. Under the influence of the REACH legislation, many SVHCs in new plastics have already been replaced, but the substitution of certain efficient additives is not straightforward.

By compounding, the composition of recyclates can be adjusted. During the compounding process, (virgin) plastic or specific additives are added, whereby the composition and properties are altered. However, compounding is rarely carried out by recycling companies themselves, this additional process increases the recyclate price, which further decreases the possibly interesting price difference between recyclates and quality virgin plastic. This is completely different if a recycling company works closely with a producer of virgin plastic or a chemical company which can provide the necessary knowledge and substances to increase the quality of the recyclates.

As previously mentioned, the compounding option will be applied more and more by the large producers of virgin plastic. In this way, they can also remain the most important raw materials suppliers for plastics processors, in a circular economic model. Not only will the recycled content of their various compounds be known. Both the processability and the final product properties of their "virgin plastic with recyclate content" will be guaranteed. Technical support for their customers in terms of complaints, innovation, process optimisation, etc., will be retained.

The diagram below shows a general mechanical recycling process (according to the definition of **ISO 15270**) for thermoplastic polymers which, depending on their form via melting or other processes, can be used again.



This diagram does not show all possible recycling processes, but nevertheless provides a good overview of the various processes that can be used.

Which recycling processes will be used will be determined by various parameters including:

- The availability and the quality of the (selectively) collected material,
- the level of soiling of the material to be recycled,
- the appearance of the form in which the polymer waste is presented (film, sheet, fibre, object, etc.),
- the desired area of application of the recyclate,
- the production process (processing) in which the recyclate will be applied, etc.

Not only can the mechanical recycling process be applied to thermoplastics, but also to thermosets and fibre-reinforced composites. This rarely occurs because these are rigid and sometimes abrasive materials which wear out the machines used to reduce the material more quickly.
Because thermosets are not meltable, the reduced thermosets can usually only be used as (functional) filler in thermoplastics, bitumen, concrete, etc.

The operations to recover and recycle plastic waste flows into plastic recyclates can consist of one or more of the following processes:

- manual or mechanical sorting on the basis of visual recognition of certain products
- stripping of electrical cables - removing the polymer jacket around electrical cables
- automatic detection of the chemical polymer composition and/or colour of certain products and the pneumatic, mechanical or electrostatic removal of unwanted products. The current

applied online detection systems can see the polymer but definitely cannot determine the chemical composition of the recyclate.

- the reducing (grinding, shredding, chopping, fraying, etc.) of recovered materials,
- the separation of various materials (different polymers, present impurities or metal, etc.) on the basis of one or more specific properties such as density, magnetic properties, electrostatic charge, conduction, etc.,
- the customised sifting of reduced material into particles of a certain dimension,
- homogenisation or agglomeration of recovered materials,
- washing (reduced) materials,
- extracting impurities by means of solvents, supercritical fluids, etc.,
- chemical decomposition of any impurities present: e.g. ozonisation of plastic waste can decompose a number of aromatic substances.
- drying or thermally treating reduced material to remove moisture or volatile substances that may be present in the recycled material.
- melting and (re)granulating recyclates.
- compounding: during the melting of the recovered plastic, other polymers and/or additives are added whereby "formulated granules" are created.

Complex or assembled items (devices, vehicles, installations, etc.) can contain multiple polymers. Various polymers which are not chemically bound together, can be separated from each other during recycling. Separating different polymers can be done by exploiting differences in properties such as density, electrostatic charge, etc., However, additives in plastics can alter the polymer properties which certain separation techniques rely on.

The table below gives an overview of existing separation techniques and their application in industry, with regards to post-industrial and post-consumer plastic waste respectively. 'Applicable' should be understood as meaning the extent to which this process is used industrially for sorting plastic waste (on a scale from 1 = barely applied to 5 = very frequently applied). 'Efficiency' should be understood as meaning (also on a scale from 1 = low to 5= high) the extent to which this technique is able to sort a specific material flow from a mix, with as few false negatives or positives as possible. This table is composed on the basis of the expert opinion of the practitioners themselves, after contact with companies in the sorting industry.

Overview of the various separation techniques and their industrial applicability			
Separation technique	**Applicability post-industrial**	**Applicability post-consumer**	**Efficiency**
Flotation	5	5	4
Selective flotation	2	1	4
Flotation with magnetic fluid	2	1	3
Flotation supercritical CO2	2	1	3
Water table	5	4	4
NIR optical sorting	5	5	4
X-ray optical sorting	5	5	4
Raman optical sorting	3	1	5
Electrostatic sorting	5	5	4

Centrifuge	5	4	3
Hydrocyclone	5	4	3
Windsifter	5	4	3
Multidune	2	1	3
Fluidised Bed	2	1	3
Dissolving and precipitation	2	1	4
Thermo adhesive	3	1	3

Which processes are actually used depends on the type of material, the input quality and the desired output quality. The viability of many recycling processes is determined by the batch size, the quality of the input material (recovered materials), whether or not the installations are automated, etc.

Although these techniques already allow an initial separation, it will also be necessary in the future to achieve a more "refined" separation. While the separation techniques mentioned above can differentiate between most polymers, all polymers differ from each other based on their additives.

If it is the intention to not only recycle easy waste flows (such as PET bottles, HDPE bottles, PVC products, etc.) into raw materials, as is currently the case, we will have to optimise and improve various recycling techniques.
The ecological aspects of certain recycling processes (e.g. washing yoghurt pots, washing soiled foil, etc.) and the energy consumption of certain techniques (e.g. cryogenic grinding of rubbers) will also need to be looked at in much more detail.

Innovative projects focused on recycling and enhancing more complex or contaminated plastic waste flows need to be encouraged and supported in the context of the circular economy. Recycling these waste flows is necessary to improve the material recycling score. As long as only uni-composite plastic products are recycled, the circular economy for plastics will remain limited.

The **ISO standard 15270** provides guidelines on the recovery and recycling of plastic waste. The standard **EN 13437**, specifically aimed at "Packaging and material recycling" establishes a number of specific criteria regarding recycling methods, as well as for the definition of recycling processes and the associated flow charts

Plastic recyclates can take various forms. The most well-known recyclates take the form of regrind, flakes, agglomerates, pellets, compounds, and micronised powder.

The "recycled content of plastic recyclates" (recyclate as a product) is 100% in principle unless there are a significant amount of foreign substances present, which will be removed in any case during subsequent processing (for example by the use of filters on an extrusion line which do not allow certain non-meltable particles or dirt to pass through) or if the plastic recyclates undergo a compounding process whereby non-recovered raw materials such as virgin polymers, natural fibres or non-recycled minerals are also used.

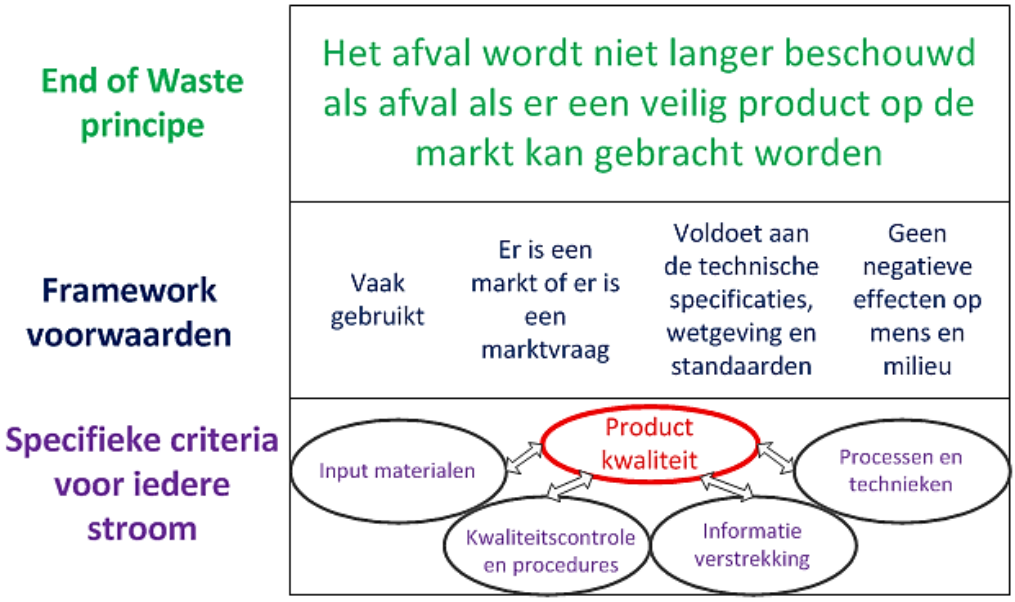
The recycled content of recyclates relates to the full composition of the recyclates and clearly not just to the polymer content.

The supplementary addition of other "recycled materials" (e.g. mineral fillers that are created during the purification of ores) to recycled polymer products can increase the recycled content of the plastic recyclates.

Waste undergoing one or more recycling processes stops being "waste" at a certain point, and becomes "raw material". Knowing the "waste - raw material" turning point is not always clear. The turning point will always be towards the end of the process.

In order to rule out confusion, technical working groups at the European level intend to draw up "End Of Waste" criteria. The **EOW criteria** need to indicate whether certain waste flows are sufficiently enhanced or converted to be used as raw materials. The presence of unwanted substances (dirt, metals, SVHC substances, etc.) will be an important element in establishing the definitive EoW criteria.
For the time being, EoW criteria will only be drawn up for waste flows for which an (almost) certain market exists.

The most important criteria and the procedure which will be used when developing the EOW criteria is presented in the chart below.



Bron: Final draft report JRC-IPTS 3/2013 EoW for waste plastic for conversion

Framework directive 2008/98/EC also defines these four basic conditions for the "End of Waste" approach in article 6, and indicates that this must be ensured, inter alia, for various polymer materials/products, namely "pellets, rubber tyres and textile".
The important criteria are "product specific quality aspects" of both the input material and the recyclates produced.

There are currently no approved EoW criteria for polymer waste and recyclates.

In 2012, JRC developed a "proposal" with regards to EoW criteria for plastics. This proposal (which has not been approved), which was explained in the Plastic ZERO report "Market conditions for plastic recycling" (LIFE program), sets out the basic elements: (http://www.plastic-zero.com/media/30825/action_4_1_market_for_recycled_polymers_final_report.pdf)

- the quality of recovered plastics:
    - the waste to be recycled must meet customer-specific specifications or industrial specifications for direct usability in conventional plastic processing techniques in which the recyclates are melted. For the identification of the most common polymers, the familiar standards will be applied (see below)
    - Non-plastic substances such as metal, paper, glass, natural textile fibres, sand, bitumen, ceramics, wood, etc., which were not yet enclosed in the polymer matrix can be a maximum of 1%. Non-plastic additives which were already present in recycled products are not taken into account.
    - The products to be recycled may not contain any SVHCs (see below)
    - The waste may not contain any visible substances such as oil, solvents, paint, adhesive, or solid or liquid food residue.
- Unauthorised waste for the recovery of materials or products for recycling includes, inter alia, medical waste, used hygiene products and materials.
- Treatment processes and techniques
    - The incoming materials from producers, traders and collectors which will be used as input for the recovery of materials, must be kept separately and must not be mixed with other waste.
    - The applied recycling processes (unbundling, sorting, separating, reducing, purifying, regranulating, etc.) on certain input flows need to be fully undergone in order to create raw materials which can be used immediately in industrial processes.

Recycled materials based on **biodegradable or compostable polymers** are excluded as plastic recyclate.

The exclusion of biodegradable and compostable polymers is logical because these materials are not stable enough to be used without issues in conventional plastic processing such as extrusion or injection moulding.
The problem with these unstable polymers is their possible presence in plastic waste that is mechanically recycled. When the concentration of such plastics in the total product is too large, the result is recyclates with poor stability and quality.
Note that many conventional polymers, mostly made from oil, can also be made via the bio-route. These plastics, which are also sometimes referred to as "bio" plastics, have in principle identical properties to those made from oil or natural gas, and can of course be converted into recyclates.
There are also conventional polymers which, by adding certain additives, become degradable, or due to UV or external weather conditions, can be more easily decomposed to microplastics. The plastic products based on these formulations (also referred to as oxo-degradable polymers) would also have to be excluded from raw material recycling.

3.2 Application of recyclates

The application of recyclates occurs for various reasons.

When recycled plastics are used in the same product as those from which they are recovered, it is referred to as **closed-loop** recycling. As such, the recycled plastics are used:

(1) <u>To replace homologous virgin polymers</u>
This either occurs 100%, or only as a percentage (usually the case). If the used recyclates only replace part of the normally applied polymers in new products, and are also processed together with virgin polymers during the production process, then in principle these recyclates need to be:

- compatible with the virgin material. Any impurities present are usually incompatible.
- able to be processed with the same processing parameters
- have the same properties as the virgin polymers which they replace as much as possible, at least for the properties which are ultimately intended to be in the new product. For food-grade plastic applications, it is of course extremely important that the recyclate fully meets all criteria.

As previously mentioned, recyclates are almost always "formulated plastics" which never fully have the same composition as the homologous plastics. The presence of, for example, pigments or colourants can hinder the use of recyclates in visible components. The addition of supplementary pigments and colourants can provide a sufficiently homogeneous colour image in RC products. Coloured recyclates can also be used in non-visible interlayers. Virgin polymers are only applied to the surface of new plastics. "in mould-labelling" technology can also be used to make the underlying coloured plastic invisible.
Closed-loop recycling is generally considered to be the most ideal form of recycling. Most applications of plastics require recyclates which do not have impurities or ingredients which can be released from the polymer matrix. The presence of impurities or certain additives may hamper the usability of recyclates in the same area of application (e.g. packaging, construction, …). For food packaging materials, the absence of impurities is essential.

The fact that PET bottles are colourless and the absence of disruptive ingredients are major advantages, which also explains the very high recycling scores of PET drinks packaging.

The ad infinitum potential for recycling the same materials in products presupposes that the polymeric raw materials will not be decomposed either when in use and during the recycling process. However, unlike metals, organic polymers will always degrade during recycling and reprocessing (at least partially), which can have a significant influence on quality. As such, plastics cannot be endlessly used one-on-one to replace their virgin counterparts.

Applying a pre-treatment to the recycled raw material, such as for example removing disruptive impurities, decolouring or restoring the original chain length (with so-called 'chain extenders') is often described as "up-cycling" and is mainly applied to closed-loop recycling.

In principle, closed-loop recycling of non-REACH-compliant products is not permitted. All new products which come onto the market must be REACH-compliant (see below). But the "controlled closed loop recycling" of certain products containing SHVCs could be a solution

for non-REACH-compliant products to tolerate not just thermal recycling (incineration). The controlled closed loop recycling of such products could be seen as a process for responsibly extending the life of these products, and respecting the hierarchy agreements within the waste legislation. This can be an interesting avenue, but is only useful if it can also be accepted at the European level, and only applied under strict conditions.

When recycled plastics are used in a product different from the one from which it was recovered, it is referred to as **open-loop** recycling. There are various options in this respect:

(2) Plastic recyclates are used as a raw material to replace another polymer, in a high quality application. For example: the underside of fitted carpets is usually made from PP fibres, but the needle felt that is used can also be made from recycled PET-fibres. The prices of R-PET and virgin PP will determine which polymer is actually used for the production of the fibres of the needle felt. Such open-loop recycling, whereby the application is considered 'high-quality', is also referred to as 'side cycling'.

(3) Recyclates of mixed polymers (e.g. PP/PE mixtures, the so-called MPO - mixed polyolefin) can also be 100% used in certain products without the addition of other polymers. In the development of such products (e.g. pallets, street furniture, beams and planks for jetties, the protection of coasts or river banks, etc.) supplementary additives may be added, taking into account the necessary stability. In many cases, such products are very solid and more resistant to external influences (weather conditions, water, etc.) than conventional wood products which are also applied for these purposes. Unfortunately, producing such products is often described as "downcycling" due to the large amounts of plastic which are used in a product which is merely robust.

(4) During the production process, recyclates can be combined in a targeted manner with other polymers to achieve, for example, highly specific product properties. For example, polyamide recyclate can be combined with polyethylene in high-quality products with a very high resistance to electrical arc discharges. The intimate mixing and combining of different polymers usually requires the addition of special additives which ensure the necessary homogeneity. The combination of polymers at the melting level ensures that they can no longer be physically separated in a subsequent recycling process, for which there is disagreement as to what extent this is side-cycling or downcycling.

With regards to the distinction between different types of recycling, the authors strongly advocate the use of the **neutral terms closed-loop** and **open-loop** recycling instead of the more subjective terms up and downcycling.
The distinction between closed and open-loop is made at the product level, and is entirely neutral. If a material is used in the same application again, it is referred to as closed-loop recycling. All other cases are open-loop recycling. The latter is not a judgment on whether the new product is of high quality or not.

Recommending "closed-loop recycling" under strict conditions and for specific products or areas of application may be useful for example in the context of protecting potential users, or the environment (see below). However, open-loop recycling is in many cases a very feasible option for the best use of the secondary raw material.
On the other hand, the terms **up** and **downcycling**, immediately imply that 'up' is good and 'down' is bad. The boundary between both is also decided **subjectively**, based on the perception

of the new product. It is primarily individuals outside the plastics processing industry itself who are, for example, quick to label the re-processing of mixed polymers as downcycling, since the principles of Eco-design endeavour to obtain as many mono-materials as possible at the end-of-life stage. However, the reality of plastic recycling is that in some cases (e.g. multilayer packaging) it is impossible to separate the constituent parts from each other, meaning that there is a choice between incinerating for energy recovery or recycling as a mixed polymer. Recycling into a new product is undoubtedly preferable in this case within the principles of a circular economy.
It is the opinion of the authors that the use of these subjective terms can be a brake on both product and process innovation, and for trans-sectoral cooperation between the industrial (sub)sectors who could use each other's polymer waste. All forms of recycling have their added value and should be given appropriate consideration.

Via "design for recycling" and "design from recycling" techniques, the development of all possible products with recyclate content can be encouraged, along with the creation of plastic recyclates with specific properties. In this way, the value of recyclates (polymer + additives or polymer combinations) can be increased, based on all the ingredients present.
In a circular economic model, plastic recyclates need to be full-fledged raw materials like virgin plastics, which depending on their technical specifications, may be applied in a considerable amount of plastic products. The fact that additives or other polymers are already present in recyclates can no longer be seen as a disadvantage, but must be seen as an asset.

3.3 Technical specifications and standards for plastic recyclates

Recyclates are always raw materials or products purchased by plastics processors, for use in specific products that have been developed by them and that are produced with specific machines.
Only the buyers of recyclates can determine whether the proposed recyclates are suitable for actual use by them. Technical specifications or standards applicable to available recyclates will always be product and application-specific.

Establishing technical specifications for plastic recyclates, which are raw materials for production companies, is and must remain a "business-to-business" matter. Governments must not give in to the temptation to impose technical specifications for recyclates for certain products, applications or sectors. Only in cases where recyclates which (could) be harmful to the health of operators/users, or the environment, should the government take appropriate policy measures. Recycled plastic is essentially a (secondary) raw material and not waste; the material should therefore also be treated as such, including the applicable EoW criteria.

Producers expect from their suppliers that they will provide the necessary "product information", and that the recyclates will be in compliance with the applicable general laws and regulations.
Buyers rightly expect that recyclates can safely and efficiently be applied to their machine pool and that the use of recyclate in the products they produce will also not jeopardise the health or the safety of their customers.

ISO 15347 was developed for exchanging product information. This standard provides a number of minimum requirements for defining recyclate, as well as the test methods which are applied for testing additional (optional) characteristics.

The minimum product information includes:

- batch: volume or weight
- colour: description
- form: grind, film, pellets, compound, etc.
- origin according to EN 15343
- primary polymer: weight proportion if known
- other polymers present: percentage if known
- packaging form: big bag, loose in truck, container, bales, etc.

Optional specific characteristics:

- impact strength according to EN ISO 179-1 and EN ISO 179-2 or EN ISO 180
- melt viscosity (MFI) according to EN ISO 1133
- Vicat: EN ISO 306 method A
- percentage of additives, impurities, moisture content, volatile components (if known)
- ash content according to EN ISO 3451-1
- moisture content: EN 12099
- tensile strength: according to EN ISO 527, parts 1 to 3
- weight loss at the processing temperature (depending on the polymer)

A number of countries (including US, UK, D, etc.) have specific codes, definitions or classes for various recovered plastic waste flows and recyclates.

- For example, WRAP (Waste and Resources Action Programme), BPF (British Plastics Federation Recycling Council) and BSI have developed the PAS-103 specification system for collected packaging waste. These specification systems facilitate the trading of suitable waste flows for the production of recyclates. (http://www.international-recycling.com/grades/Plastic%20PAS103.pdf)
- Germany has established a number of categories for plastic waste, such as 310 for plastic films, 320 for mixed plastic bottles, 321 for polyolefin plastic bottles and containers, etc., For each category, there are a number of parameters such as max. 8% impurities for cat. 310, less than 4% other plastics, no metal objects, etc. These specifications are explained in Annex V of the JRC report. (http://susproc.jrc.ec.europa.eu/activities/waste/documents/EoWPlasticsfinalDrepMar2013WEB.pdf)

It could be useful to develop a European classification system which would be applicable in all EU countries. However, recycling companies that are active in several EU countries have learned to live with the existing systems in certain countries, and have supplemented these in many cases with their own specifications or purchase/sales conditions. Every recycling company which is aware of the specific capabilities and limitations of its recycling processes has clear acceptance criteria for the waste flows which they can process.

The "optional" technical specifications indicated in ISO 15347 are interesting data for all plastics processors. The large buyers of recyclates make clear agreements with their recyclate suppliers in this regard, depending of course on their machine pool, product mix, and purchasing conditions.
In general, it can be said that most recycling companies cannot (yet) provide the same service to plastic processors as the producers/suppliers of virgin polymers. The producers of virgin polymers are aware of this, and consequently have a growing interest in offering polymer compounds with recycled content.

The quality checks mainly concern the physical properties and characteristics, which are mainly important in the context of pricing, such as the percentage of "non-plastic" particles, total dry and wet weight.

The **EN 15343** standard handles specific procedures which are used for the **traceability and assessment of the conformity** of mechanically recycled plastics.
The traceability requirements pertain to:

- inspection of incoming material (selective collection system, sorting diagrams, batch identification, origin of waste, entry inspection data
- inspection data of recycling process(es): process parameters, product inspection results
- identification of recyclates according to polymer-specific standards **EN 15342** for PS, **EN 15344** for PE, **EN 15345** for PP, **EN 15346** for PVC and **EN 15348** for PET.

The standards **EN 13430 and EN 13437** pertain to the recycling of packaging.

- EN 13430 indicates which recovered packaging can be recycled, as well as the procedures which need to be applied for assessing compliance with the applicable requirements.
- EN 13437 defines the criteria for a recycling process and describes the main mechanical recycling processes.

Because a lot of packaging materials are used for the packing of food and drink, specific legal requirements must also be taken into account (282/2008/EC), as well as regulations and controls for such packaging material.
The European PET bottles platform (www.petbottleplatform.eu) has developed specific guidelines for the recycling and testing of PET bottles.

Because the above-mentioned standards only establish agreements in the area of traceability and specifying conformity, they cannot be used as such as EoW criteria.

Since the supply and application of plastic recyclates is a B2B matter, the technical specifications determined by the parties concerned must continue to apply.
Additionally, specific legislation must of course be taken into account with regards to certain waste flows (WEEE, ELV) and product policy (RoHS, REACH, CLP, POPs).

The recycling and production companies are downstream users of polymers and compounds. They have little or no infrastructure and resources to have the conformity of their recyclates or products continually assessed themselves. Product and company certification (see below) must be seen in their context.

3.4 Applicable legislation for recyclates

A significant amount of legislation has been enacted to protect human health and limit and possibly further reduce the environmental impact of waste (by setting objectives). Of course, the production and use of recyclates must not undermine these regulations. Not only is the legislation applicable to waste and recyclates briefly explained below, but a number of remarks or possible additions are also provided.

Packaging and packaging waste guideline 94/62 EC and 2004/12/EC

The objective has been set to reuse and recycle 50% of household packaging made of paper, glass, paper and plastics by 2020. EoW regulation intends to promote up-cycling as well as increase recycling scores for packaging material.

The increase in the recycling score from +/- 30% to 50% is a huge challenge for plastic packaging and will not be possible without comprehensively adapting the way in which recyclates are collected, recycled and used.
A large amount of packaging material is related to products such as food, drink, detergents, hygiene products, etc., which are consumed very quickly. Due to our lifestyles and work and household habits, the proportion of plastic packaging continues to grow. Most of the packaging material currently recycled consists of only (or mainly) 1 polymer (PET, HDPE, LDPE). Moreover, a very large proportion of this is not body-tinted, which facilitates the recycling and usability of recyclates.

But also in this regard, there are clear material changes which will not make the recycling of plastics any easier.

- The body-tinted plastics and the proportion of decorated packaging and smart packaging is increasing, and new polymers will also become more important (https://www.kidv.nl/over-het-kennisinstituut-duurzaam-verpakken/pers/4818/pet-wordt-vervangen-door-pef-biobased-verpakken-centraal-in-verdiepingsbijeenkomst-kidv-verpakkingsmanagement-maart.html&field=Binary1).
- All contaminated plastic packaging (yoghurt pots, trays, etc.) and the more advanced (smart) packaging (barrier layers, functionalised plastics, RFID, etc.), IML packaging (In-Mould Labelling) and body-tinted plastics are now generally incinerated. The recycling of these more difficult flows will significantly hamper the closed-loop recycling process of conventional packaging materials. Due to the application of other polymers and new additives, up-cycling will become a concept that will need to be interpreted differently.

The REACH compliance of packaging materials for food, drinks and household products will not be a problem because all new packaging with a short lifespan which is produced and recycled in Europe is REACH-compliant in any case. If the recycling and production activities of packaging materials moved to other continents, then the fact that REACH compliance would no longer be a given would have to be taken into account.

Cross-border shipments of waste – WSR 1013/2006

For the export/import of various waste, specific lists are applied. Most plastics, with the exception of PVC, can be found on the green list.
By understanding clear EoW criteria, a number of materials will no longer be considered as waste. For plastics which are part of electrical or electronic equipment, and vehicles, different legislation is applicable (WEEE and ELV).

The development and implementation of a European coding system for EoW plastics would likely facilitate policy and monitoring (control and registration).

Waste Electrical and Electronic Equipment (WEEE) directive 2002/96/EC

This legislation targets the removal of hazardous waste as well as the recovery and recycling of

critical materials, but does not specify to what extent any plastics present can be recycled.

Due to the broad area of application, the number of different WEEE plastics is very diverse. Many plastics are no longer simply the housing of devices or are an efficient electrical insulating material. For example, in order to obtain the desired properties (electrical conduction, LED, solar cells, etc.), a growing number of plastic sheets are coated with organic coatings or inorganic overlays (e.g. ITO, OLED, LCD, etc.) and consequently acquire a specific functionality.
Since heat is generated in many WEEE applications, many fire retardant additives are used in the plastics. However, the most effective fire retardants are specific halogen compounds which in the context of the RoHS and REACH legislation (see below) can no longer be used. It is not always possible or straightforward to replace these additives.

The plastics with brominated fire retardants (tetra, penta, hexa, hepta and octa BDE) should be separated.

Certain WEEE devices such as conventional household telephones (not mobile), vacuum cleaners, kitchen appliances (coffee machines, etc.) and larger household appliances (washing machines, tumble dryers, refrigerators) contain no or very few plastics with brominated flame retardants. The mixed group of such household appliances rarely has more than 0.1% polybrominated diphenyl ethers.

However, other devices such as TVs, computers, power tools, photocopying machines, printers, adapters, etc., usually contain plastics with much more fire-resistant additives (usually SVHCs). Such devices and equipment should in principle be sorted.

A distinction is not currently made between "safe" and "SVHC-containing" plastics, neither during manual dismantling of WEEE, nor during shredding or via conventional post-treatments (e.g. flotation).
By applying special detection systems (XRF, Raman) or adapted flotation-separation systems, it should in principle be possible to separate FR plastics from shredded plastics. But these possibilities are either not known or not (yet) implemented at the WEEE recycling companies, meaning that the demonstrability of REACH compliance for WEEE recyclates is currently problematic.

The controlled closed-loop recycling process for non-REACH-compliant WEEE plastics could possibly be a solution under strict conditions for European WEEE recycling and production companies. Unfortunately, the number of European WEEE producers has become very small. This approach is only useful if it can be controlled at the European level.

End of Life vehicles – ELV directive 2000/53/EC

The main ELV objective, recovering 95% of the material from end-of-life vehicles, is feasible, due to the presence of a large amount of metal (engine block, bodywork, wheels, etc.).

Depolluting end-of-life vehicles consists of releasing hazardous liquids and removing certain components. Depolluted vehicles are then shredded. The light fluff fraction (plastics, textile, foams, etc.) is currently further purified (removal of non-ferrous metals, dirt, separating by density, etc.) but the rather bulky residual fraction after purification is usually incinerated or landfilled.

Due to the increasing proportion of plastics (see table below, source European Plastics Converters) in vehicles and certain carbon fibre-reinforced composites, it may be desirable to dismantle (manually or with robots) certain technical plastic or composite parts.

Plastics used in a typical car

Component	Main types of plastics	Weight in av. car (kg)
Bumpers	PP, ABS, PC/PBT	10.0
Seating	PUR, PP, PVC, ABS, PA	13.0
Dashboard	PP, ABS, SMA, PPE, PC	7.0
Fuel systems	HDPE, POM, PA, PP, PBT	6.0
Body (incl. panels)	PP, PPE, UP	6.0
Under-bonnet components	PA, PP, PBT	9.0
Interior trim	PP, ABS, PET, POM, PVC	20.0
Electrical components	PP, PE, PBT, PA, PVC	7.0
Exterior trim	ABS, PA, PBT, POM, ASA, PP	4.0
Lighting	PC, PBT, ABS, PMMA, UP	5.0
Upholstery	PVC, PUR, PP, PE	8.0
Liquid reservoirs	PP, PE, PA	1.0
Total		**105.0**

In the context of an OVAM investigation into "recycling certificates" as an innovative economic instrument for waste and materials policy, policy measures aimed at recycling shredder residue and the selective dismantling of car parts was considered.
(http://www.ovam.be/sites/default/files/FILE1364989216827ovor130403_Eindrapport_Recyclagecertificaten.pdf)

Verifiability and the susceptibility of recycling certificates to fraud, associated with the reimbursement of certain taxes on the one hand, and the possible distortion of the market on the other, are important points of consideration.

RoHS directive (Restriction on Hazardous Substances) – 2002/95/EC and 2011/65/EU

This directive intends to restrict the use of certain substances, especially in WEEE, in order to encourage a cleaner recycling flow.
Since 2006, new equipment may no longer contain lead, mercury, cadmium, chromium 6, polybrominated diphenyls (PBBs) and polybrominated diphenylethers (PBDEs). For these elements there are certain maximum limits. For PBB and PBDE, this is 1000 ppm (0.1%). There are a number of exceptions for which no alternatives exist.
What is currently offered for recycling has not necessarily been produced after 2006, meaning that the recyclate must continue to comply with the RoHS legislation.

REACH and CLP legislation

REACH (EC 1907/2006) is the European legislation on the Registration, Evaluation, Authorisation and Restriction of chemical substances. CLP (EC 1272/2008) refers to Classification, Labelling and Packaging.
Both regulations are intended to be means of communication regarding the trading and use of dangerous and harmful substances. The registration and authorisation of chemical substances is always carried out depending on specific applications (for example, certain pigments are

registered for use in plastics, if the intention is also to use these pigments for paint, this area of application must also be indicated). In the event of trans-sectoral use of recycled materials, it must always be ascertained whether this is possible. The registration and authorisation of substances takes place at the European level.

REACH is not only designed to protect the health of people and the environment, but also to promote alternative methods for assessing harmful substances and facilitate the free circulation of substances.

This guideline is not only important for producers of chemical substances, but also for recycling and production companies. This directive is also applicable to downstream users. A number of exceptions are made to registering certain substances such as polymers, waste and natural substances. Polymer combinations and polymer alloys do not need to be registered either. The synthetic additives used in polymer products must be recorded and possibly authorised for one or more of the areas of application (plastics, textile, coatings, etc.).

None of this excludes the possibility that the recycling companies need to draw up safety sheets for the recyclates they produce, or have a communication obligation to indicate the presence of certain harmful substances (SVHC - Substances of Very High Concern) in recyclates or mixtures of recycled materials.

The REACH document CA/24/2008 rev.3 of April 2009 on "waste and recovered substances" provides more clarity regarding recycled polymers. Harmful SVHCs present in recyclates cannot be considered as impurities but as substances which require the necessary attention. The companies which recycle recovered materials and recyclates must inform their customers as to which SVHCs are present, and in what concentrations. The communication obligation only applies for recyclates and plastic products containing more than 0.1% SVHCs.

Recyclates made from "recent" plastic products which by definition are REACH-compliant, are likewise generally REACH-compliant. In any event, the chemical substances which are present in the plastic structure are not altered by mechanical recycling. This automatic compliance with REACH can only be guaranteed for recyclates made from products which are made of 100% virgin materials and REACH-compliant additives. Due to the constant expansion of the SVHC list, checking REACH compliance remains a focus point for recycling companies.

Please note that this is only valid if the recycling takes place in Europe. If the recycling takes place on another continent and the recycled materials were re-imported, it would have to be proven that these recyclates are REACH-compliant.

If the recyclates are made of "older" plastic products which contain (at least according to the current REACH legislation) substances which are no longer authorised, these need to be considered in principle as products with SVHC content (and for which the communication obligation is applicable).
If chemical processes (hydrolysis, glycolysis, etc.) are applied during recycling (e.g. for feedstock recycling), it must also be ascertained whether these chemical processes generate SVHCs. If the chemical processes are intended to extract or alter the SVHCs present, it must be verified whether these chemical processes have actually succeeded.

Since REACH legislation is a work in progress, recycling companies always need to check whether

certain waste flows are authorised for recycling and/or whether the recyclates are still REACH-compliant.
REACH may also curb the use of certain substances in certain applications.
The restrictions which are applicable to plastics include:

- the use of low molecular weight phthalates in toys
- the use of cadmium in recycled PVC in a number of specific construction applications
- the use of cadmium in crates
- the use of lead in PVC
- the use of PAH (Polycyclic aromatic hydrocarbons)

Similar restrictions are also in place for various substances in textile products.
When synthetic textile products are used to create recyclates for plastic applications, it needs to be checked whether or not this is possible in the new intended application.

We would like to refer to the recent RIVM report "Plastics that contain hazardous substances: recycle or incinerate?" (http://www.rivm.nl/Documenten_en_publicaties/Wetenschappelijk/Rapporten/2016/maart/Plastics_that_contain_hazardous_substances_recycle_or_incinerate).
This report discusses in more detail the use of Hexabromocyclododecane (HBCDD) as a fire retardant in EPS polystyrene, and plasticisers, cadmium and lead in PVC pipes.

It is recommended that the solutions for the recycling of materials is given a legal framework. The RIVM report calls for a harmonisation of the various legislations with which the substances must comply. For example, it is advisable to involve the waste policy and the policy for hazardous substances in their respective working areas, and look at the entire recycling chain to identify where there are any obstacles. The establishment of working groups made up of REACH and recycling specialists is essential, as is the setting up of research with regards to exposure risks within the various product and process phases.

This recommendation could also be applicable to other polymers with other SVHCs.

In addition to the conclusion of the RIVM report, we also want to highlight the controlled closed-loop recycling avenue of products which do not comply with REACH legislation. If this manageable avenue could be approved at the European level, it could avoid the incineration of old polymer products (high temperature incineration is currently the only definitive solution to dispose of these non-REACH-compliant products). Controlled closed-loop recycling would equate to extending the lifetime of the non-REACH-compliant products, for which there is no current destruction obligation. By adding supplementary virgin and REACH-compliant additives during closed-loop recycling, the SVHC content in the new products could be reduced and the stability could be increased. Whether this avenue could be applicable for all products and all SVHCs is a matter which still needs to be explored.

Additionally, when recyclates containing SVHC as packed are placed on the market, these need to comply with CLP legislation.

POP – Stockholm Convention and POPs regulation

POPs, Persistent Organic Pollutants, are chemical substances which accumulate in the environment and affect the health of people and damage the environment via the food chain. This is especially relevant for recyclates from marine litter, such as PA recycling from fishing

nets.
POPs can be found inter alia in pesticides (DDT, etc.), hexachlorobutadiene, PFOS (perfluoro-octane sulfonate), paraffins with short chains, polybrominated fire retardants, and by-products of industrial processes such as dioxins and furans. Many of these substances are covered by the REACH legislation.

3.5 Sustainability considerations with regards to recycling and recyclates

Recycling processes and the resulting recyclates of course have their own specific environmental aspects and impacts, which depending on the type of material, any soiling present, the origin (post-production or post-consumer), the logistical processes, the specific area of application, etc., are not negligible.

Specifically this means that the conversion of plastic waste flows into recyclates via mechanical recycling processes is neither economically nor ecologically responsible in certain cases, at least with the current state of technology, and that other recycling processes (conversion to fuel, chemical substances) or incineration would be preferable.

Specific LCA analyses can substantiate such allegations or refute them. For many waste flows there is still no reliable information that can be used in LCA studies.

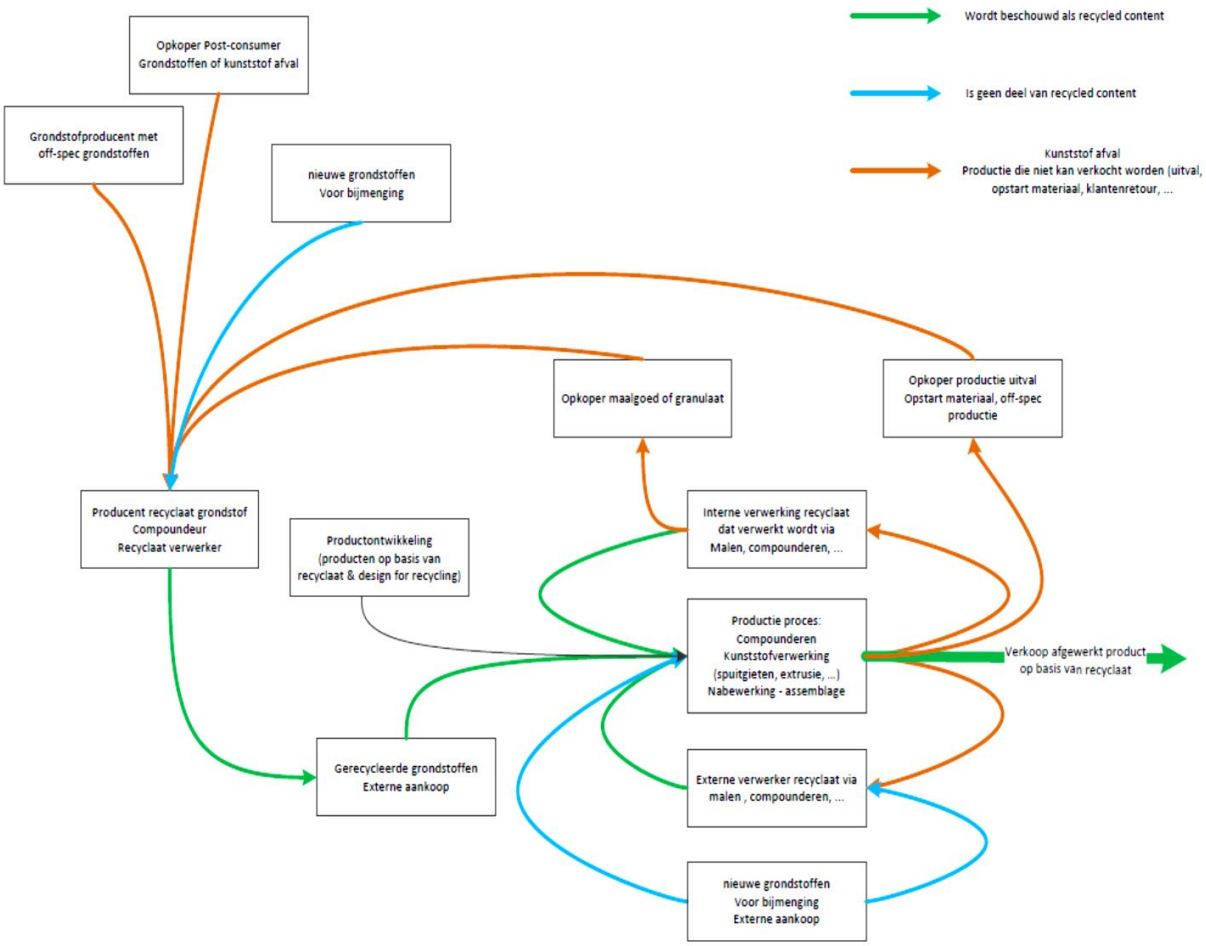
4 Products or objects with recyclate content

The encouragement of material recycling also presupposes the encouragement of the development and production of goods with recyclate content, as well as the marketing of RC products.
Moreover, "Recycled Content" can be an important instrument.

4.1 Material flows which could possibly be used for products with recyclate content

Before going more in-depth into the calculation and interpretation of recycled content in products or objects, we want to chart the various material flows using a diagram, and discuss which of them could qualify as a raw material for new plastic products, and for the calculation of the recyclate content of new products.

The diagram below shows the production of plastics with all the corresponding material-related in and outputs.



Provided there are minor adjustments in terms of the designation of processes or materials, this diagram can also be applied to the production of other polymer products such as textiles, composites, etc. Recyclates of polymer waste flows from the various sectors concerned (plastics processors, textile companies, composite producers, etc.) can be used both within and between these sectors. Extrusion waste from textile companies can, for example, be used in injection moulding processes.

Depending on their use history, certain material flows can be described as "pre-consumer" or "post-production" waste, others as "post-consumer" waste.
According to their place of origin or storage, certain materials can be described as "internal" or "external" waste.

Certain materials should be considered as "waste", "recovered materials", "recyclate" or "raw material".

- This specific division is not so important for the production itself but because other, usually more stringent, legislation may apply to certain materials, this division may be necessary in many cases.
- Due to the presence of certain substances (e.g. certain phthalate-plasticisers in PVC or brominated fire retardants in various plastics), some waste can become "hazardous waste", which needs to be registered internally as such, and in principle stored, collected and processed in isolation.

The material flows within this diagram always assume a "supplier" of materials or a "producer" of materials (recyclates), plastic products based on virgin materials and/or recyclates (RC products) or of composite items (also installations and construction works) consisting of various RC products.

These material flows can be divided into 3 types of flows, which we have given a different colour for the sake of convenience.

(1) The **material flows indicated with green connection lines** can be considered as material flows which qualify as recycled content.
Before they are used in the production process, these materials have undergone one or more recycling processes, either by the producer itself, or by an external recycling or environmental company which supplies recyclates.
Internal and external recycled materials both qualify, with the exception of degradable materials whose stability is uncertain.
The recyclates themselves can be generated by the mechanical recycling of both post production (pre-consumer) and post-consumer waste.

(2) The **material flows indicated with orange connection lines** relate to products, materials or objects which **cannot be sold for their intended purpose** and which will be recycled by the producer itself or by a third party. However they may become RC products further down the chain.
These flows include inter alia production waste, start-up material or production changeovers, moulding or other accessories, which are produced at the same time but are not sold along. But they also include damaged, rejected, expired and/or returned goods, which "as such are no longer saleable", or goods which at the request of customers or authorities cannot be "marketed" (e.g. counterfeit goods, confiscated goods, obsolete branded products which are withdrawn from the market, etc.).
Such "non-saleable goods" can either be internally or externally recycled into re-usable

materials for production, but could also be destroyed.
Products which can be sold in sales, or as 2nd or 3rd class products, are not, however, eligible for the calculation of recycled content.

(3) The **material flows indicated with blue connection lines** relate to new (virgin) raw materials and can never be considered as recycled content. Virgin raw materials produced by a raw materials producer which are downgraded for whatever reason as being non-compliant (e.g. due to process failure or the use of an incorrect ingredient, or the virgin material might not be in compliance with the applicable specifications), but which can still be sold to buyers as virgin material, also cannot be used as recycled content.
Consequently, compounds based on virgin polymers and recyclate can only consider the proportion of recyclate as recycled content. Only the materials which undergo one or more recycling processes can be considered as recyclates.

The best way to interpret the diagram above is starting from the **producer** who wants to produce or assemble materials, RC products/items and who also has an interest to characterise these goods as such, or have them recognised as such.

- In order to produce materials, products or items with recycled content, the producer has a production machine to produce such goods. In principle, the production process can also consist of various process steps, but for the sake of convenience these multi-step production processes are shown here as a single activity with a number of in- and outputs.
- For the production of such goods, the producer may, in addition to new raw materials, also use (complete or partial) recyclates.
- The recyclates which the producer uses can be made internally via an additional machining process (e.g. grinding, compounding), or they can be purchased. Note that in certain definitions (see below) or according to certain parties, internally produced recyclate is not taken into account for the calculation of the recyclate content.
- The purchased recyclates may or may not originate from their own unsaleable products, start-up materials, rejected products, etc., but can of course also be supplied by a recycling company or another producer which produces recyclate from post-production and/or post-consumer waste flows. Combining post-production and post-consumer polymer waste is a possibility for improving the quality of the recyclate.
- Producers of virgin materials who recycle their rejected materials or purchase external recyclate can therefore, in addition to virgin materials, also place "recyclate" on the market. They can also highlight this specific portion of recycled material as recycled content. Only the specific recycled content portion can be taken into account as recycled content by the buyer of such mixtures.
- Recyclates may or may not have the same chemical composition as the virgin materials which are used in the production process.
- Recyclates are not (formulated) thermoplastic polymers, but may also be other recycled materials such as reinforcement fibres (wood, glass, carbon, etc.), minerals (conventional fillers), finely ground thermosets, functional additives, plasticisers, etc., which are added during the production process.
- The sum of all the materials present which are already enclosed in the polymer matrix is considered as recycled content. The sum of the additives in the polymer matrix can, in principle, be larger than the polymer portion of the recyclate.

All recovered materials which have undergone recycling processes could possibly be taken into account for the calculation of the recyclate content. For various environmental reasons, taking into account all other recycled waste flows (retaining energy content, optimising material use,

reducing CO_2 emissions, etc.) and managing the level of quality and production costs, are all desirable.
The buyers of such materials or RC products, as well as clients, authorities or certification bodies, can make it clear that only certain recyclates will be taken into account for the calculation of the recyclate content of pellets or RC products.

The produced goods can be referred to as materials, products, items (devices, equipment, vehicles, etc.) or even constructions, which in principle can take all kinds of forms (3D plastic, fabric, film, etc.), colours, compositions (consisting of one or more polymers in which there are one or more other substances) and building structures (layered, core/jacket structures, etc.). Items and constructions may contain various components which may or may not be easy to dismantle.
The various materials, each with a different chemical composition, can be homogeneously or heterogeneously distributed within a product or component.
The whole product or only some parts of it can be made on the basis of virgin or (partly) recycled materials and these recyclates can be made from pre-consumer and/or post-consumer waste.

The term 'recycled content' can be applied in principle to the whole product, item or construction, or only on certain parts of components.

For hybrid products (e.g. cars, coffee machines, TVs, etc.) which contain completely different materials (e.g. metal, plastic, glass, etc.) with highly varying densities, the recyclate content would, for example, only be calculated on the plastic fraction itself. This could be useful, given that all the metals present are recycled materials (made from scrap), which furthermore account for a considerable proportion of the total weight of the product. The "recyclate content of only the used plastic parts" will always be limited in terms of the total product weight of composite items. By only putting the RC focus on the plastic fraction, it will be possible to monitor more effectively whether recycling targets for plastic materials are being achieved or not, and to adjust accordingly.

4.2 Recycled content – EN 14021

The **EN 14021 standard** defines "**recycled content**" for a product, material or item as the ratio of the mass of "recyclate content" in relation to the total mass of the produced material, product or item multiplied by 100.
The internal reuse of material which can immediately be used as such, or after internal (in-line) grinding, in the still-active production process, is excluded from this standard.

The term 'recycled content' can only be applied to products in which recycled materials are processed, but also to plastic recyclates themselves.

- Making this distinction is perhaps superfluous because recyclates are also products, but it is nonetheless interesting in the context that certain certification systems (see below) exclude specific material flows.
- The focus of certain certification systems on recyclates made on the basis of post-consumer waste is useful because quality assurance for the recycling of post-consumer waste is organised separately. For the (internal or external) recycling of pre-consumer waste, the composition and purity of the materials are very well known, meaning that a compliance assessment is much easier. The usability of "pre-consumer recyclate" in new products rarely throws up problems, which clearly cannot be said for post-consumer recyclates. Adding pre-

consumer recyclate alongside post-consumer recyclate improves the stability of the new plastic.

It could be questioned whether excluding "internal recyclate", as is the case in the EN 14021 standard, is a good idea for the production of RC goods. It usually concerns minor quantities (in most companies, less than 5% and maximum 10%). Moreover, a producer has no financial advantage in producing more waste internally, which can then be used for the production of RC products. The production cost and material cost for converting virgin material into internal recyclate is too high.

Some certification systems such as Eucertplast (see below) not only exclude internal recyclate, but also all recyclates based on pre-consumer waste. Others apply a correction factor (e.g. 0.5) for the use of pre-consumer waste (for the LEED ID+C certification, only half of the post-production waste used can be calculated).
The exclusion of post-production waste among some certification systems or the application of a correction factor of 0.5 is a decision which especially targets the use of post-consumer waste in the production of new materials. For polymer products, this very strong focus on post-consumer is not appropriate, since post-production recyclates have a known composition, ensure product stability and quality, and help to achieve the primary objective of recycling, namely reducing the consumption of oil-based virgin polymers, conserving energy as much as possible, and reducing CO_2 emissions.

If recycled content was only confined to products made with recyclates on the basis of post-consumer waste, many producers would be excluded who make major efforts to limit the use of virgin material in their products as much as possible.

By only allowing post-consumer recyclates, the effect moreover is to encourage production of a limited number of specific products (PET bottles, HDPE bottles, etc.) which are currently well recycled, or of non-critical products which can almost entirely be made with mixed recyclates from post-consumer waste.

There are also buyers who only accept closed-loop recyclates in the calculation of recycled content. This approach is currently only feasible for a very limited number of materials and products such as PET drinks packaging and HDPE bottles. Since plastics were not designed to be recycled over and over again, a 100% closed-loop situation will always be finite in nature. Plastic products which can be closed-loop recycled almost always require the setting up of very expensive selective collection systems. By (over)emphasising closed-loop recycling, a limited number of polymers are inadvertently favoured, which are currently the most suitable, while other polymers become "inferior", at least in terms of recycling.
It must be ensured that emphasising the closed-loop approach as the ideal material recycling does not put a brake on product innovation. Product innovation needs to be based on both open and closed-loop recyclates. As previously indicated, controlled closed-loop recycling can indeed be a possible solution to no longer having to incinerate certain non-REACH-compliant polymer products, but using them instead as material in new products. Of course this would only be possible under strict conditions.

Since recycled content can be an interesting policy instrument to help solve the plastic waste problem, it is important that producers of various RC products also support it.
It would appear useful in the context of a circular economy to authorise all material flows which

can replace virgin materials, but which of course comply with all legal provisions, and with any B2B specifications which are established. Specific quality and other requirements which could or must be applied to specific RC products will be discussed in more detail.

The standards **EN ISO 14021 and EN 15343** indicate not only how recycled content needs to be calculated, but also clearly indicate that the recyclate content of products, which claim a specific recyclate content, must be based on a transparent **traceability system** (materials flows and production data) and an internal **quality assurance system** (ISO 9001 or analogous QA systems), focused on:

- monitoring the in and output quality
- demonstrating and ensuring the compliance of the produced goods with the applicable product standards or specifications
- the introduction of targeted process controls of the applicable recycling and production processes.

The **traceability** of specific data and the determination of **compliance** are key elements in the subject of recycled content.

Mindful of this importance, the **EN 15343**[1] standard was developed with regards to traceability, and assessing product compliance.

If the production and marketing of **RC products** is based on a private **label or environmental declaration**, **ISO 14021** is applicable. This standard defines best practice for companies to avoid producing misleading environmental declarations, and to use the correct labelling. These declarations need to be accurate and verifiable. Labelling and environmental declarations must inspire confidence in consumers and other stakeholders, and facilitate the international trade of products with recyclate content.

Both for buyers/consumers who have an interest in RC products, and for governments who wish to pursue a specific government policy concerning "recycled content in (specific) products", the reliability of the information on the recyclate content is paramount. Specifically, this means that the producer, or whoever places RC products on the market, must not provide misleading information on RC products. This information will always be product-specific. If the intention is to demonstrate product compliance with certain standards, the information must always clearly indicate which standards it is referring to. If environmental criteria, labelling or declarations are used, these need to be clear.

The general booklet by the German government regarding environmental information for products and services may be useful in this respect. This practical booklet clearly indicates where attention needs to be given regarding information and labelling. (http://www.bmub.bund.de/fileadmin/Daten_BMU/Pools/Broschueren/umweltinfos_produkte_dilei_broschuere_en_bf.pdf)

It cannot be ascertained with current analysis techniques whether a plastic is a virgin or recycled raw material. The analysis techniques make use of IR absorption peaks of functional groups in polymers. Since both virgin polymers and recyclates exhibit these polymer-specific IR absorption peaks, no distinction can be made between the two. Virgin and recycled

[1] This standard is essential for the users of this report. Since summaries and broad outlines can always result in misunderstandings, these standards are not merely explained in brief.

polymers typically have slightly different melting behaviour but because they cannot be separated from each other, this analysis is not discriminatory enough to determine the presence of recyclates.
The analysis of plastics is usually carried out according to the chemical composition of the polymers present, while the presence of other substances (fillers, specific additives such as stabilisers, fire retardants, etc.) is rarely examined.

Due to a lack of suitable and affordable analysis methods for recycled raw materials, the recycled content and its composition in products, materials or objects can only be determined in cooperation and consultation with the producer.
Only the producer of a given product knows its exact composition and the recyclate used within it. For composite products containing both metal parts, electronic components, plastic housing, buttons, etc., which can each have a different recyclate content, the information for each part or component needs to be requested separately. However this is not always possible, since many components are made outside Europe and some components are also "black box" products. To protect certain products, producers are not always willing to disclose the exact composition of their products.

The calculation of the recyclate content will always be based on information from the producers concerned.

For the calculation of the recyclate content of a composite product (e.g. coffee makers, washing machines, etc.), it must be clear precisely what needs to be known regarding the recyclate content (as a percentage of the total product, or just the plastic fraction). It also needs to be indicated which types of recyclates are accepted or not for the calculation of the recycled content. In annex, a calculation sheet has been added with which the RC of composite products can be determined, both in terms of the plastic fraction and the full product. The application of this calculation sheet can highlight the importance of certain elements (internal recyclate, pre-consumer and post-consumer, composition of the recyclate, additives, etc.).

In the context of sustainability, Philips has developed a new Senseo® coffee machine in which as much plastic recyclate as possible is used, without altering the aesthetic appearance of this well-known appliance. The link below shows how Philips succeeded in using certain recyclate components (base plate: 90% post-consumer WEEE-plastics, plastic covering 13%).
http://www.philips.com/a-w/about/sustainability/sustainable-planet/circular-economy/senseo-up.html
In order to calculate the recyclate content of these appliances, the weight composition of all the utilised components must be known (plastic elements and other materials), as well as the total weight of the appliance. For each plastic component that can be made from a different polymer, it needs to be known how much recyclate has actually been used. For the production of the Senseo plastic components, only post-consumer-based recyclate is applied.

In theory, the exact product composition can be requested by any stakeholder, but many producers are reluctant to simply disclose this information. Since the use of certain materials or components can be imposed, other aspects can of course be specified in Specification documents or purchase conditions, such as the provision of information concerning precise product composition and processes. This is usually performed by buyers who are well informed about the materials and processes used.

Only by carrying out spot checks on the producer and examining/requesting specific data and registrations on site, is it possible to ascertain whether the information with regards to recycled content is correct.

In order to provide sufficient reassurance to consumers or other parties concerning the exact composition and recyclate content, the producer may consider having a specific product, material or item certified by an independent party (inspection body or certification body).
In addition to this "product certification", the company or production unit can also become certified itself (system certification).

The various product and/or system certificates are explained in more detail in Chapter 5.

4.3 Quality of products with recycled content

The potential procurement of a recycled content label does not affect in any way the obligation of the producer to ensure these RC products comply with general product legislation and the applicable requirements or specifications.

Any possible authorisation or promotion of such a label on certified products, or the clear inclusion of RC criteria in the European Eco-label system will only have an effect on consumer behaviour if this labelling is sufficiently well-known and also sufficiently transparent in terms of content and relevance for the consumer. The use of RC labelling and declarations is currently not enshrined in law. To avoid the proliferation and misuse of such labelling and declarations, the development of relevant legislation is desirable.

The technical specifications of RC products are usually established within the area of application or a certain business sector, but can also be formulated by the client/customer/government, or presupposed as such.
The significance of technical specifications (and tolerances) for a given product is not always obvious. For many consumer products or packaging of consumer products, these data are merely indicative. However for functional goods or critical products, specifications have a much larger significance.
Technical specifications in a B2B situation usually have a binding character. Non-compliance or insufficient compliance of a material or product with the imposed requirements can easily give rise to complaints, the rejection of goods, the termination of a collaboration, etc.

Not only do RC products need to comply with generally applicable **quality specifications** (determined by the producer, the buyer, the market or a third party) but also with the **legal obligations**.

This means specifically that products with recycled content need to be just as safe, and cannot affect the health of users, as identical products without recycled content.

REACH compliance of RC products is an obvious requirement. For most of the polymer products based on recyclates which are produced in Europe, this is not a problem, unless the recyclates they use contain SVHC components.

For RC products which contain more than 0.1% SVHCs, there is a communication obligation. If

the product is made up of several components which can easily be dismantled or separated, this obligation applies in principle to each component.

Certain products must naturally also comply with specific regulatory requirements or directives such as CE marking, the Machinery Directive, the Packaging Directive, the Construction Products Directive, product liability, etc.

Producers are always responsible for demonstrating product conformity with the applicable laws and for drawing up product specifications.

A focus point for producers of products, materials or items with recycled content is having adequate knowledge of recyclates and recycled raw materials with regards to specific material properties, in comparison with that of analogous or identical virgin materials.

- This knowledge is necessary to know whether the recycled materials still have the desired properties and were not (partially) degraded in their previous life.
- Adding additional stabilisers or other additives to recyclates may be necessary to obtain the same properties of those of virgin materials.
- For goods with a long expected life, the additional stabilisation is of course much more important than for goods with a more limited life, such as packaging material which is usually only used for a few months. For raw materials in products, materials or objects which can frequently be recycled, knowledge regarding the effect of multiple recycling on the raw material properties is essential.
- If the used recyclates have the same chemical composition as the homologous virgin materials, it can be desirable for critical products (e.g. certain automotive parts) and products with a long expected life (e.g. in construction products) to add special additives such as compatibility agents, repair agents, crosslinkers, stabilisers, anti-hydrolysis agents, etc. Such additives should fully or partially restore any possible degradation of materials, or should prevent any impurities or foreign polymers present in the recyclate from hindering homogenisation, or from catalysing the ageing process.

Since the knowledge indicated above is generally limited among many plastics processors, a number of producers of virgin polymers are increasingly interested in producing "RC compounds" themselves, and marketing them on the basis of (new) virgin polymers and recyclates.

Monitoring and, if necessary, adjusting the product quality is the exclusive responsibility of the producer, or the distributor who markets the product.

It is therefore essential to make the implemented input, process and product controls traceable, determine compliance, and take corrective measures in the event of complaints or if shortcomings are identified.

4.4 Sustainability of products with recyclate content

Recycled content is generally used to highlight or promote the "sustainability" of a given product, or to showcase certain ecological features.
Especially in the context of **"green procurement"** which can be stimulated by the government, or to influence the buying behaviour of certain consumers, it is possible to strongly emphasise the ecological aspects and sustainability of products with recyclate content.

Sustainability is a relatively new concept within society, but one which can also be abused by certain producers or distributors. In light of the "greenwashing" phenomenon, the familiar **ISO 14020 standards** were developed.

The **ISO 14020** standards aim for international harmonisation with regards to allocating and using **environmental labelling and declarations** as well as promoting the associated advantages. This series of standards intends to:

- counteract the abuse of or misleading character of:
    - environmental labelling (Type I environmental labelling – **ISO 14024**),
    - self-declared claims of producers and commercial organisations (Type II self-declared environmental claims – **ISO 14021**)
    - formalised environmental data which emphasise certain environmental aspects and environmental benefits of products (Type III environmental declarations – **ISO 14025**). The environmental data will be based on guidelines and requirements laid down in the **ISO 14040** series regarding environmental management and lifecycle analysis **LCA** (ISO 14040, ISO 14043 and ISO 14044)
- encourage the market potential for environmentally friendly products and services and facilitate the associated international trade,
- better inform consumers so they can make responsible choices.

In order to counteract possible abuse, it is important to draw attention to the responsibilities of the declarant (usually the producer who claims to produce products with recyclate content, or who labels products as such) concerning the evaluation of comparative testing, the methods used and the accessibility of information which demonstrates or underpins the sustainability of products with recycled content.

Criteria which are used with regards to certain products or services

- to refer to them as sustainable,
- to positively discriminate them for public procurement contracts,
- to benefit from different taxation,

generally include economic, ecological and social criteria.
In the context of sustainable procurement – guidance, the recent **ISO standard 20400** (2016) is interesting literature.

Ecological aspects are examined, both for "product certification" and "system certification of companies", which are applicable to the recycling of used waste flows and/or for the production of materials, products or objects with recyclate content.
Most certification organisations require that the recycling or production company applies an ISO 14001 or EMAS management system.

5 Certification systems focused on recycled content and recyclates

There are currently certification systems that have been developed or applied for the certification (1) of recyclates, products with recyclate content or (2) of companies which produce and/or market such goods. Both product and system certification by an independent third party must provide the necessary reassurance with regards to RC products and their production.

Product certification is focused on the assessment and evaluation of a specific product with regards to the applicable requirements (standards, specifications, legislation). System certification assesses and evaluates whether a company is competent to provide the necessary guarantees, or whether the RC products produced by them comply with the applicable requirements.

In principle, both systems can be applied in the event of market inspections, the assessment of tenders, etc., Of course, the certificates still need to be valid and clearly need to relate to the products in question. System certification clearly receives significantly more attention among production companies. Their procedures for the receipt of their goods, checking the conformity and quality of the goods they produce, the training and further education of their staff, product development, machinery adjustments, etc., are applicable to many different products. All these companies also have a clearly defined traceability system and are also familiar with external controls and audits. These companies also usually have external product analysis reports. For companies which make multiple products, product certification is usually more expensive than system certification.

Both product and system certification (and certainly those which are applied to plastic recyclates) is recent, and is usually further refined depending on audit experiences.

"Product Certificates" are much more well known in the US, presumably because various US states have pursued a purchasing policy (green procurement) for more than 20 years which favours RC products over identical products without recyclate content. Most of the certificates in the US relate to RC products and not to recyclates (authorities purchase RC products, but not recyclates with which products are made).

In Europe, "company certificates", which are focused on quality and environmental protection, are much more well known. A number of certification organisations which award ISO 9001, ISO 14001, MKB certificates (scrap metal companies), etc., to companies, have developed a specific certification system for the development and production of RC products. Companies have an interest in these company certificates since they are closely related to the familiar ISO certificates.

- Since companies which recycle plastic products usually specialise in the conversion of specific waste flows into specific recyclates, the company certificates of recycling companies are indirectly related to the recyclates they produce. Their certificate always indicates which recyclates they can produce, and in what quantities.
- Producers of polymer products (plastics, textile, composites, etc.) usually have a machine pool for the production of many different RC products. Separately certifying each specific product results in high costs, meaning that producers choose system certification instead of product certification.

- The application of a different purchasing policy by customers or governments (procurement) could of course change this viewpoint. Companies would then only take product certificates for individual RC products if they provide economic added value. Many buyers of textile products require an 'Oeko-Tex' certificate for every product or product family, which states that a given product does not contain any harmful substances. This certification is a voluntary decision for the producer. But because these certificates are used very frequently by large buyers of textile products and governments, and are also based on independent market inspections, they have become the standard for producers who want to be active on the European market.

The various certification organisations do not necessarily use the same methodology and sometimes focus on very specific target groups of companies (e.g. recycling companies) or specific products (construction products, WEEE, etc.).

Demonstrability, traceability of used data and QA management are extremely important audit elements in almost all certification organisations.

- In order to check **traceability**, most systems are based on the **ISO EN 15343** standard.
    - Traceability of material is usually "batch" or "lot" related. A batch or lot can be related to a container park, supplier, producer, recycling company, etc., but may also consist of a collection of several subunits (bale, container, lorry, etc.) Unlike physical products or objects, the identification of waste material or recyclate is usually not possible. This is usually done via the packaging or the location. Clearly defining what is meant by a batch or lot, and how the different batches or lots are distinguished from each other, is an important consideration during certification.
    - Traceability relates not only to the origin of the waste from which recyclates are made (pre-consumer and/or post-consumer), but also the quality controls of the in and outputs.
    - In cases of constant recycling or production processes, and in cases of compounding and/or mixing of material lots, or of recyclate/virgin mixtures, complete traceability is not always possible. In such cases, the application of strict process and production controls are necessary.
- **QA management** during the production of recyclates or products with recyclate content includes various management and control systems. Most audit systems for certification are based on the requirements of ISO 9001. Naturally, a company can apply its own analogous system to guarantee the quality of its goods and services.

However, not all certification organisations apply the same ISO or EN standards when assessing products, and definitely not with regards to the definition and calculation of recycled content. Certain certification organisations authorise all waste flows which are compliant or which can be made within the applicable legislation, whilst others exclude specific waste flows by definition.

The companies which choose a specific certification system or certification organisation usually do this for one or more reasons:

- A specific system (e.g. Eucertplast, RIOS/R2) is relatively popular within a specific sector (recycling companies),
- By having a given certificate in their possession, they can prove that they comply with legal obligations (WEEE take-back obligations),
- The authority concerned can encourage or require a given system (e.g. LEED, Greencircle),

Company certificates are often used by associations or organisations to demonstrate achieved (sector or agreement-specific) recycling objectives, or to highlight certain areas of application for products with recyclate content.

We would like to explain a number of the existing certification systems in more detail. A summary table will be presented at the end. It can be surmised from the survey of companies and associations, and also from literature data, that there is generally little awareness of these certification systems in the industry. A limited number of targeted systems are an exception to the rule (Eucertplast among Belgian plastics processors).

5.1 Eucertplast

Eucertplast is the European certification system focused on plastic recycling.

This system was developed as part of an EU project (within the eco-innovation programme – Sep. 2009 until Aug. 2012), with a budget of €760,000. The originators were PRE (Plastic Recyclers Europe), EPRO (European Plastic Recycling Organisation), EUPC (European Plastic Converters), EuPET (European Association Unoriented PET-film), and Recovinyl. In the context of a European project, 25 recycling companies were audited.

This certification system intends to encourage transparency with regards to recyclates, and provide quality guarantees to plastics processors. The conformity assessment of the produced recyclates in relation to the applicable EN standards, and the recycled content of the recycled plastics should provide this guarantee.

For the production of recyclates, only post-consumer waste is taken into account by Eucertplast. These recyclates may contain virgin material and pre-consumer waste, but the flows cannot be taken into consideration as recycled content.

The audit system is described in detail in the document EuCertPlast Audit Scheme - version 3.7., which can be found online (http://www.eucertplast.eu/uploads/downloads/audit-scheme-3-4-english.pdf).

The standards EN 15343, 13347, 15342, 15344, 15345, 15346, 15348 are used in the assessment of plastic recyclates which are produced by the certified recycling companies from post-consumer waste.

The following elements are assessed during the audit:

- Operational and environmental permits
- Training, qualifications of staff and organisation
- Procedure and checks for incoming materials
- Inventory management
- The recycling process and associated mass balance
- Checks of recyclates
- Environmental protection
- Subcontracted work
- Quality management and traceability.

The various certificates of the recycling companies, which confirm their annual quantities of recycled materials, are used by sectoral organisations or European associations (e.g. PVC processors) to:

- Document whether or not sectoral objectives or voluntary agreements have been achieved (e.g. recovinyl)
- confirm to authorities which determine that certain waste flows can actually be recycled.

Additional information: www.eucertplast.eu

The Eucertplast database (situation as of May 2016) shows that 93 certificates have been awarded at the present time to 81 companies with one or more recycling processes.

- 8 companies (including Vogt Plastic, Renolit and Gerflor) had certificates for multiple branches.
- Most of the certificates were awarded to companies based in Germany (33% of certificates). 11% of the certificates related to Dutch establishments, while France and Italy each had a share of 10%.
- Only 3 Belgian companies currently have a Eucertplast certificate, namely Deceuninck NV - Diksmuide establishment for the recycling of rigid PVC), IVC - Avelgem (Unilin group) for the recycling of soft PVC, and Rymoplast - Lommel for the recycling of HDPE.

Using the Eucertplast database, we can also see the companies which recycle one or more polymers.

- 58 companies only recycle one polymer type (18 recycle flexible PE, 16 PVC, 16 PET, 5 HDPE and 3 PP).
- 35 establishments recycle multiple polymers or mixtures of polymers (mixed plastics).

5.2 TUV Rheinland / DIN CERTCO

TÜV-Rheinland/DIN CERTCO, a certification organisation for primarily German and Dutch companies, has developed a product certification programme "Produkte aus recyceltem Material" in accordance with DIN EN ISO 14021 and DIN EN 15343.

This product certification system is focused on certifying recyclates and products with recyclate content (DIN-Geprüfter Rezyklatgehalt).

When certifying recyclates or products, considerable importance is given to REACH compliance.

The traceability has to start at the sorting centres for (household) waste, but the preparation of the (household) waste, which is then converted to recyclates, is not certified.

All companies which are involved in the recycling process from the sorting centre stage need to be checked, with the exception of trading companies which do not process the material themselves. These trading companies are however responsible for providing the necessary information within the certification process.

Additional information: www.dincertco.de

Currently, TUV has certified 2 products from 1 company.

5.3 UL

UL is an American multinational organisation with branches in various European countries. UL certifies, validates, tests, verifies, inspects, audits, advises and provides training on various safety aspects of materials, products, installations, etc.

UL Krefeld (DE) has a large department focused on plastics. They support production companies, plastics processors and OEMs (car manufacturers, major producers of household appliances such as washing machines, fridges, etc.) during the development and testing of plastics and materials which can be used for this purpose. Many Tier 1 suppliers of car parts, large car manufacturers and the main producers of household appliances (washing machines, fridges, etc.) work together with them, especially for the compounding of materials and the use of new materials or recyclates.

By certifying RC products, UL primarily aims to give consumers an insight into the increasing complexity of the supply chains of various materials and products, and the legislative nature of the corresponding transformation processes, applicable traceability and the demonstrability of compliance with the applicable legislation.

In their activities focused on plastics and components, they have developed a certification system (UL 746 C and D) for recyclates produced on the basis of pre-consumer and/or post-consumer waste and for products with a recyclate content.

Their certification targets recyclates and products.

The UL audit system focuses especially on the traceability of the relevant data regarding the incoming and outgoing material flows, but also include specific tests on recyclates and/or products made from them.

The test procedures, as well as the number of samples that they need to test, vary according to whether the recyclates are produced with pre-consumer or post-consumer waste flows. (Only 3 samples of post-production recyclates in contrast with 5 samples of post-consumer recyclates are tested).

The certificates must provide sufficient reassurance to plastics processors and consumers that the recyclates can safely replace virgin polymers.

Additional information: www.ul.com

5.4 SCS Global Services

The certification system of the Californian organisation SCS "Recycled Content Standard V7" focuses on the certification of products with recyclate content from companies which make claim emphatic environmental benefits for these products (type II environmental claims and labelling). They mainly focus on construction materials and products which are used in the context of the CalRecycle programme and the "US Green Building Council (USGBS) Leadership Energy and Environmental Design (LEED) Green Building rating system".

The SCS system is based on the EN ISO 14021 (Environmental labelling and declarations – Self-declared environmental claims) and US-specific legislation (Title 40: Protection of the environment part 261).

Their certification system does not assess any safety and health aspects, nor the performance of RC products. Only the recyclate content is important.

The environmental effects which are examined do not currently take account of LCA data which

are applicable to produced goods.

Important audit elements are:

- Traceability
- Separating non-compliant materials and products
- Describing the production process with an indication of the various in and outputs.
- Material characterisation:
- Qualitative: based on tests by the producer/supplier, supplier's verification and validation, supplier's data
- Quantitative: material deliveries, mass balance, waste scores and reuse of produced waste, inventories

Additional information: www.SCSglobalServices.com

The SCS Global Services (US) database shows that (situation as of May 2016) primarily specific polymer products/product groups are certified which can be purchased in bulk. The most important certified products with recycled content are:

- *Textile yarns (based on R-PET),*
- *Floor covering (primarily PVC)*
- *Materials which are used in composite materials (e.g. CORIAN) which are used as work surfaces in kitchens and in bathroom furniture. The producers of these materials have various colours or product compositions certified.*

The large number of SCS certificates relates to the specific situation in California (CalRecycle), where certified RC products appear on lists which are used by government services to find sufficient information for their specific purchases. Being able to consult certified products naturally makes it easier to make decisions, or to request additional information from companies or from certification organisations. The registration of these products also helps to see in which areas there are many or perhaps no RC products available.

RC products which are certified by SCS Global services are not only polymer products. The government has divided the products it needs to purchase into 11 different product families (including plastics).

5.5 QA-CER (Quality Assurance of Content and Eco-data of Recycled materials in polymer products)

The QA CER certification scheme was developed by BQA (Belgian Quality Association - an approved certification organisation for the certification of companies for ISO 9001, ISO 14001 and MKB systems) in cooperation with the accredited laboratories of Centexbel and the Flemish Plastic Centre (VKC).

The certification system, drawing on the standards EN 15347, 15343 and ISO 9001, is focused on the certification of industrial companies that produce and/or apply polymer recyclates in melting processes.

The QA-CER system is applicable to:

- Sorters and recycling companies of both pre-consumer and post-consumer waste from

plastics, textile or composites,
- Plastic processors, textile and consumer goods producers who use polymer recyclates,
- Assembly companies which make assembled products with recyclate content.

The certificate is awarded to a company for all or part of its activities. The certificate has 3 different levels

- level 1: management aspects of recyclate flows and applications without chemical analysis of the materials
- level 2: level 1 + guarantee of technical specifications of recyclates or products with recyclate content. This level includes external product controls by an approved laboratory.
- level 3: level 2 + check of eco-data and presence of hazardous substances (REACH and/or RoHS compliance).

Additional information: www.bqa.be

In the past year, the Belgian Govaerts Recycling (Alken) and Beaulieu Technical Textiles (Comines) were certified by BQA in accordance with the QA CER certification system.

Govaerts Recycling *is a collection and recycling company for plastic and rubber waste. Using the recyclates they produce (a mixture of PP + HDPE / LDPE), their sister company Govaplast produces, inter alia: street and park furniture as well as a variety of other products including anti-parking bollards, plastic planks for terraces and fencing, jetties, floor boards, etc. Their products are 100% post-consumer recyclate products.*

Via the QA CER certificate level 2, they want to demonstrate that the products made from the recyclates they produce are definitely not inferior. The goods produced by Govaplast are equivalent to identical products made with virgin polymers. Through their design department, they demonstrate that full-fledged products can be made with recyclates.

Beaulieu Technical Textiles *is a producer of various technical textile products such as carpet backing, agrotextile, construction textile, geotextile, packaging, etc.*

Via the QA-CER certificate level 1, they intend to:

- *document their post-production waste flows across the various Beaulieu branches, and monitor and reuse them in a variety of high-grade products with recycled content,*
- *ensure the quality of the recyclates they produce,*
- *support innovations of products based on recycled raw materials,*
- *guide continuous improvement processes in the area of recyclate production and/or production of products with recyclate content*

5.6 US Certification systems focused on construction materials and products, buildings, building infrastructure, maintenance and other activities – GreenCircle and LEED

The development of these certification systems was catalysed by the US Environmental Protection Agency (EPA), to use more recycled materials in the context of protecting natural raw material sources, reducing energy and CO_2 emissions.

In the context of the targeted "green buildings", materials, products or entire buildings and infrastructure can be certified.

The GreenCircle and LEED certification systems should be placed in this context. These systems are mainly applied in the US and Canada.

The LEED system (Leadership in Energy and Environmental Design) is a globally recognised "green building" certification system which was developed by the US Green Building Council (USGBC). This system assess various building aspects such as design, construction, use and maintenance of buildings, houses and the home environment. Additionally, the environmentally responsible and efficient use of energy and raw materials are important assessment criteria.

The LEED system is briefly explained via the web link below.

(https://en.wikipedia.org/wiki/Leadership_in_Energy_and_Environmental_Design)

GreenCircle is a US certification organisation with various certification systems. Their product certification systems relate, inter alia, to recycled content, recyclable materials and renewable resource content. In addition, they also certify buildings and LEED compliance.

Additional information:

www.greencirclecertified.com

www.usgbc.org/leed

5.7 Certification system focused on electronic material and products - WEEELABEX

In addition to (conventional, precious and rare earth) metals, a number of plastics are also used in electric and electronic materials and products. The recycling of WEEE from consumer electronics (which might also be incorporated into in vehicles, machinery, etc.) can provide interesting recyclates which can be reused. Because a lot of the plastics in these products are difficult to disassemble or separate from other materials, and which also often contain SVHCs (especially brominated fire retardants), a significant portion of the plastics acts as fuel which is needed for the recycling of precious metals (mainly present in computers, GSMs, and consumer electronics).

After the disassembly of certain elements (cables, print plates, capacitors, etc.), a lot of WEEE is immediately shredded. It is possible to separate certain plastics from various density fractions by means of flotation and other separation techniques.

If certain elements are disassembled manually, it is possible to separate larger plastic parts of given household appliances. In order to ascertain the possible presence of hazardous substances (plasticisers, fire retardants, heavy metals, certain stabilisers, etc.) in WEEE plastics, special detection systems need to be applied. This does not currently happen, or only rarely.

In the European context, more stringent requirements are justifiably imposed for the recycling of end-of-life electrical and electronic devices.

The standard 'Waste of Electric and Electronic Equipment Label of Excellence' (WEEELABEX) is the standard for compliance with the obligations of the WEEE directive (2012/19/EU). This standard imposes requirements to the entire process chain. The aim is to recover as many raw materials as possible, with the necessary consideration for the environment.

WEEELABEX-certified companies, like all other WEEE processors, are obliged to register all the e-waste that they process with a National Register, whereby all processed volumes can be justified to the government. This is necessary in order to achieve the European collection objectives.

The WEEEBALEX certification system, like the EUCERTPLAST certification system, was developed through the implementation of an EU project (Life programme - 2009 - 2012) by a European

grouping of producers and processors.

The WEEEBALEX standard, which is also used, describes the procedures for recycling and processing end-of-life electrical appliances and electronic equipment. Waste of Electric and Electronic Equipment Label of Excellence (WEEELABEX) accurately incorporates the term 'Proper Treatment' which is required in the European directive.

Additional information:
www.sgs.be
www.weeelabex.org

5.8 Summary table Certification systems

Certification system	Product certification	System certification	accredited organisation	Product conformity (tech. Spec.)	REACH compliance	Material flows/users
Eucertplast		X				Post-consumer plastics – Only for recycling companies
TUV-Rheinland	X		TUV	X	X	Pre and post-consumer plastics
UL	X			X		Pre and post-consumer plastics, textile and composites Recyclates + products
SCS	X			X		Post-consumer plastics
QA-CER		X	BQA	X	X	All materials having undergone recycling processes - focused on recycling and production companies
GreenCircle	X			X		construction products
LEED		X		X		certification building or infrastructure
WEELABEX		X				WEEE recycling companies

The RC certification systems are especially focused on demonstrating the traceability of the data used to determine RC, and on managing the product quality of recyclates (important for recycling companies) or RC products (important for producers).

Most European certification systems are recent systems which have only been implemented among a limited number of European companies. These systems are primarily focused on the more effective management and improvement of the quality of recyclates. Above all, these systems must give confidence to production companies to use post-consumer recyclates. The interest among production companies for high-quality recyclates is increasing, but remains confined to a very limited number of plastic applications for the time being. If the availability and quality of recyclates continues to grow, the usability of recyclates in new products will also grow, as well as the interest in developing and certifying more RC products.

Due to the limited number of RC certificates among production companies, it can generally be stated that the existing certification systems (both product and system certification) are practically unknown to European consumers.

If the transition from a linear to a circular economy becomes a reality, the importance of RC products will also increase among consumers.

Finally, we would like to state that the current certification systems do not take into account the possible presence of nano-particles and/or rare metals (e.g. indium, tungsten, etc.) in certain

plastics or in thin coatings on plastic films.

5.9 REACH compliance and certification

Emphasis on REACH compliance is limited or non-existent in most certification systems. This is definitely the case for American systems (REACH is irrelevant for US companies), and among the European certification organisations, only TUV and QA-CER place the necessary emphasis on REACH compliance. This lack of emphasis on REACH compliance can be attributed to the very limited focus of most recyclers on REACH and the lack of the necessary equipment and knowledge to determine themselves the REACH compliance of recyclates or RC products. Most recycling companies with an interest in product or system certificates focus primarily on the recycling of well-known waste flows (e.g. usually uni-polymer packaging materials or certain construction products), meaning that the REACH issue is not generally a problem. Waste flows which they do not know, or for which they know that problems may arise, are not recycled (and are either incinerated or exported). If the recycling score for plastics needs to increase, recycling companies will also need to give attention to these waste flows and give much more attention to REACH compliance in the future.

But emphasis on REACH is also (too) small among production companies. Most produced goods contain a large amount of virgin polymers and REACH-compliant ingredients which are procured in Europe. Additionally, the recyclates which they use are primarily based on pre-consumer plastics (which are also REACH-compliant) and/or on a limited number of well-known recyclates (mono-composite or PP/PE mixtures with little or no risk of SVHCs).

6 Relevant areas of application for recycled content

The term "recycled content" can be used as:

- a policy instrument in the context of waste and materials policy, or to encourage the implementation of a circular economic model,
- a toolkit for certain public procurement contracts in the context of green public procurement of goods and/or services,
- additional product information for consumers or buyers, whereby the parties involved can possibly adjust their purchasing behaviour,
- a guideline to test, certify, validate, recognise and/or homologate products, services, installations, sites, infrastructure, organisation, etc.
- a reliable marketing instrument for companies,
- a means of discouraging or punishing misleading "greenwashing",
- a working instrument in the development of new legislation, guidelines, standards, etc.

In this chapter, we would like to present a number of areas of application for the (regional, national and European) governments. In general, it can be stated that policy measures and any objectives with regards to recycling and RC products is best taken at the highest level, namely Europe. This approach would cause the least disruption to existing markets, and avoid unnecessary cross-border transport of waste for recycling, while local networks focused on the production of RC products could be strengthened. The European policy in this area naturally needs to be transposed into federal and regional regulations, and specific support and monitoring initiatives.

In order to avoid the misleading of consumers and to place the interpretation of recycled content in the proper legal context for all the actors concerned, the development of a specific Royal Decree for products with recycled content is advisable (see below).

Specific policy measures will be more successful if they are fully borne and supported by the parties involved. Both recycling and production companies want to actively cooperate in implementing a circular economy, in which the recycling of polymer products and the use of plastic recyclates are essential elements. Companies realise that the transition from linear to circular must be based on effective cooperation and networking between companies, different knowledge and insights with regards to product development (including eco-design) as well as on different agreements with suppliers, customers and government. Consultation between companies and authorities is necessary in developing specific policy measures which have a direct impact on the daily operation of companies in terms of materials management, product development, purchasing, production, sales and marketing, and service provision.

As downstream users of polymers and various additives, both recycling and production companies know that REACH compliance for some recyclates can be difficult. Special attention needs to be given to the possible controlled recycling of "old" products, which are no longer in line with the market following implementation of the REACH legislation, and which after collection can only be incinerated or gasified in principle.

Realism, continuity and a clear long term vision are important elements. EoW criteria for polymer waste which needs to be established at European level can be challenging, but it needs to be applied without significant additional investment in analysis equipment or external product checks/certificates. Both recycling and production companies expect that there will be adequate monitoring and supervision by the government regarding the REACH compliance of recyclates

or RC products produced outside Europe.

If there is an arbitrary imposition of an RC percentage in new products, production companies will encounter problems, especially because this is not always possible and this imposition would distort the market. Additionally, imposing RC could slow down innovation in terms of using higher amounts of recyclate.

6.1 RC Policy

In 2013, the Policy Research Centre - Sustainable Materials Management, published the paper "Recycled content als beleidsinstrument – internationale wetgevingsvoorbeelden en verdere ontwikkeling" (Recycled content as a policy instrument - examples of international legislation and further development). (https://steunpuntsumma.be/docs/recycled-content-als-beleidsinstrument). A number of conclusions were drawn from this investigation, with regards to RC (see below).

"Recycled content" as a policy measure arose, primarily in the US, as a reaction to the significant increase in separated waste collection in the 1980s. Although separate collection led to a substantial increase in recycling, many production companies were reluctant to use recycled material.

What was assumed at the time, with the exception of a limited number of uni-polymer products (PET bottles, HDPE bottles, etc.) from which industrially usable recyclates are made, is still applicable. In chapter 1 of the present report, the main reasons were given, as cited by companies, as to why the use of post-consumer recyclate is still relatively limited. Reliable quality and availability of post-consumer recyclates are important conditions for local production companies, who pursue product quality more than in the past, which cannot always be guaranteed by recyclate suppliers. It has only been possible to respond to these essential conditions for a limited number of polymers and products.

To avoid an oversupply of selectively-collected material flows which are generally only incinerated and/or landfilled, governments want demand for products with recyclate content to increase.

Primarily in the US (in various states), a "command and control" regulation was established relatively early (in the 1990s), under which a minimum percentage of recycled content was imposed in certain products (including paper, packaging, etc.). As a result, producers were obliged to purchase and use recycled materials. In the context of these regulations, arbitrary recycling objectives were imposed, which in many cases were unrealistic or not well monitored. In most states, the effects of this policy were not controlled or adjusted, and due to the market-distorting nature of some objectives, the RC policy was watered down or scrapped (except in California). The annual compliance reports of CalRecycle indicate that the recycled content issue is still alive in California. General information on CalRecycle and the underlying programmes can be found in their general booklet:http://www.calrecycle.ca.gov/Publications/Documents/1408/20110039.pdf
The success of the CalRecycle programme rests on various elements such as long-term vision, a transparent audit and certification system, support for companies, monitoring, and product information.

The investigation carried out by the SUMMA Research Centre suggests the following reasons for the failure of numerous Recycled Content initiatives:

- the (potential) RC standards to impose an RC content are not flexible. They take little or no account of market shifts and the internationalisation of economic activities which the imposition of a recyclate content entails for local production companies. This could be overcome by updating the relevant legislation at regular intervals, to bring it in line with the industrial reality.
- the (potential) RC standards are arbitrary(why a minimum of 10% post-consumer recyclate, why 50% recycled paper and not 45 or 60%, etc.). Some, generally non-critical, products can absorb a lot more recyclate. In some products, a threshold of at least 10% post-consumer recyclate is already too high to achieve the required product quality. Moreover, post-consumer recyclate is an umbrella term which fails to address the effects of possible variations in the composition of post-consumer recyclate.
- Recycled Content is not, in itself, a stimulus for innovation. Companies who continue with it are not rewarded. When companies have achieved the intended target figures, motivation to take additional steps dissipates. A graduated rating system (such as a 'star' system) could be the solution, if the added value of a high score is also tangible for companies.
- Indiscriminate RC standards which impose a minimum RC percentage to all products may lead to too much or too little output at the product level and/or non-quality products. The standards take no or far too little account of the organisational aspects within production companies and their normal procedure. The production of products which depends on the availability or not of the necessary recyclates, is not the normal modus operandi for controlling a production process. When working with virgin materials, there are no concerns as to the availability of the necessary raw materials. A circular economy, driven by recycling, will only work if the quality and availability of recyclates can be guaranteed.

However, this cannot be an excuse for not taking any specific policy measures with regards to the recycled content of products.

This RC policy needs to be focused on:

1. **Encouraging** raw materials recycling, and discouraging the thermal recycling of polymer waste. In addition, ensuring observance of the waste hierarchy is an important driver.
2. **Clearly defining** (via a Royal Decree) RC products, whereby consumers and buyers of RC products have more confidence in RC products, and producers have an interest in developing, producing and marketing RC products.
3. Granting a positive significance to RC for **sustainable procurement** by governments.

By adopting relevant policies and formulating concrete initiatives, attention will still be given to encouraging product innovation and D4R (Design For/From Recycling) and avoiding unwanted market shifts. In this context, the importance of both open and closed-loop recycling will be emphasised, avoiding the terms up and downcycling.

Encouraging raw materials recycling

Raw material recycling can be encouraged not only by making the collection and pick-up of end-of-life polymer products even more selective and more attractive for both consumers and collectors, but also by facilitating (local) mechanical recycling and discouraging thermal recycling (by making it more expensive (through taxes)).

Facilitating local mechanical recycling of polymer products (plastic, textile, composites) can be done, inter alia, by:

- implementing EoW criteria at the European level as soon as possible, not only for the 5 most used mono-composite polymers, but also for polymer mixtures and alloys which should be regarded as special polymer-grades.
- recognising independent institutions for the analysis of recyclates in the area of REACH compliance, and the certification of recyclates and recycling companies.
    - These institutions must be able to demonstrate their expertise and independence as an accredited lab (ISO 17025) or certification organisation (ISO 17021).
    - Both product and system certification systems must verify the RC-traceability of business data, as well as the quality monitoring of the in and output flows and of the applied recycling processes. The EN 13543 should be used as a guide in this respect.
    - The results of the analyses, checks and audits carried out by them must be registered internally, and must be consultable by the government in the event of dispute or doubt.
- searching at the European level for generally accepted solutions for the mechanical recycling of products containing SVHCs. According to the current REACH legislation, end-of-life or released polymer products containing SVHCs are no longer in line with the market, and are currently incinerated or gasified.
    - The conclusions of the RIVM report 2016-0025 "Plastics that contain hazardous substances: recycle or incinerate" could provide guidance in this search for solutions.
    - In this context, it could also be verified whether "controlled closed-loop recycling" of products containing SVHC is possible. This closed-loop approach could effectively be seen as an extension of the life of these products. Determining the conditions which could make this possible must of course be established. This is only possible at the European level.
- encouraging investment for the further purification of waste flows (not only purification processes but also the corresponding environmental techniques) whereby contaminated plastic flows can nonetheless be used as raw material.

Encouraging the production of RC products

The usability of plastic recyclate will mainly be determined by the availability, quality, REACH compliance and the price of recyclates in comparison with those of virgin polymers. These elements determine the price, quality and safety of new RC products to a very significant extent. But the interest of buyers for RC products and the growing importance of eco-design among production companies can also support the growth of RC products.

The government can encourage production companies in various areas to use plastic recyclates in the production of RC products. The most important are:

- Supporting all initiatives aimed at implementing a circular economy and of investments which are necessary for this transition.
- Clearly defining in a Royal Decree what RC products are, which materials flows need to be taken into account in this respect, and how the recycled content has to be calculated. Especially in the case of hybrid composite products, it is important to know whether the RC must be decided in relation to the total weight of a product or only in relation to the weight of the plastic fraction. The minimum requirements which are applicable to all RC products need to be included here (see below).
- Defining the conditions to be recognised as an independent laboratory (ISO 17025) or certification organisation (ISO 17021) for the issuance of product or system certificates relating to RC products or companies which produce and/or market RC products.
- Organising and monitoring targeted market inspections which need to supervise:

- the correct application of RC labelling or of environmental declarations with regards to RC products.
- the REACH compliance of recyclates and RC products which are produced outside Europe.

Purchases of RC products - example of an existing policy

In addition to the elaboration of a RC policy and the setting of general objectives for recycling and RC products, CalRecycle (US - California) has developed a specific directive for purchasing products with recyclate content, for its government departments which are responsible for procurement. By means of this directive, they intend to set a good example, and encourage consumers to purchase similar products.

"State agencies must purchase recycled products instead of non-recycled products whenever recycled products are available, if fitness and quality are equal, and are at the same or a lesser total cost than non-recycled products. The State Legislature has mandated that State agencies purchase goods and materials from 11 product categories".
At least 50 percent of reportable purchases are recycled products.
The reportable purchases shall meet each requirement and be applied to the total dollar amount of each specified product category. The purchase of a recycled product from one category may not be applied toward the requirements or the total dollar amount of any other category.
Reused or refurbished products should be considered 100 percent recycled and there is no minimum-content required.

The "plastics" group (one of the 11 categories within CalRecycle), which is procured by the public authorities, contains various polymer products such as cartridges, carpets, office equipment, waste containers, clothing, mats, construction products, garden material, fencing, packaging, etc. This plastic group contains not only rigid and flexible plastics but also many textile products.

- All RC products must contain at least 10% post-consumer material to obtain RC product status.
- CalRecycle has developed procedures for certifying RC products.
- The certified products are put into a list, and can be consulted online.
- Innovative companies were also highlighted, who manage to incorporate large amounts of recyclate which retain the necessary quality, or who develop 100% RC products.
- Recyclates themselves are not certified, in any case these are products which are not purchased by governments.

Purchasing RC products – developing new policy

An analogous **purchasing policy** for RC products could also be developed at the European, federal and/or regional level. If such a decision is made, it will be important to clearly define the products or product families to be purchased, and possibly illustrate them with specific examples of RC products. In the context of a circular economy, it is best above all to select the products which can be produced within local regions or Europe, and where the recycling companies can participate. The products that are most eligible are listed in annex 4.

For government procurement, a bonus system could be developed for RC products. To what extent the RC criterion should take precedence over other awarding parameters can of course

depend on the type of product and the importance of these public procurement contracts to encourage the development and production of certain RC products. In no event can the use of RC alter the desired product quality, or make compliance with legal obligations impossible.

In order to determine the RC in RC products, the following must be indicated:

- which recyclates (internal, post-production and/or post-consumer) are accepted or not,
- how the recyclate content must be calculated (on the total weight of a composite product or only the plastic fraction). See annex 5 and calculation sheet.
- which documents (product certificate, company certificate, etc.) can be accepted in order to accept RC products.

If product or system certificates are accepted, it must also be indicated which laboratories and certification organisations are recognised. Furthermore, independence and expertise are essential elements which must be demonstrated. The ISO standards 17021 and 17025 can be applied in this respect.

6.2 Minimum conditions for RC polymer products

The minimum conditions can be used during the elaboration of a Royal Decree regarding RC products, and during the elaboration of a procurement procedure of these products by governments.
The definition of RC which must be used in this context is the percentage weight fraction of recyclates in a product, as referred to in EN 14021, but without the limitation of internal recyclates. A recyclate is an industrially usable material, generated from internal or external end-of-life products, which have fully undergone one or more mechanical recycling processes.
For composite products, which are not only made from polymer raw materials, it is necessary to clearly indicate whether the weight of the complete product counts, or the total weight of the polymer fraction.

Proposal relating to minimum conditions in which all polymer products[2] (plastics, textile, composites, etc.) with recyclate content must comply with the following 3 conditions:

1. <u>Contain a certain percentage of recyclate</u>. The weight percentage within the polymer portion of a product is imposed to allow the product to be eligible for the title "RC product". It is up to the contracting authority to decide how high this percentage should be. This could be:
    a. A minimum percentage, arbitrarily imposed based on the type of product (that way, a much higher RC percentage can be imposed for example for a partition wall than for a printer)
    b. Proportional. No absolute minimum is imposed, but the higher the percentage, the higher the obtained weighted 'bonus' for RC.
    c. A combination of the two: there is a minimum RC percentage and a bonus value to be obtained for every additional step of x percent RC.

If the arbitrary system is chosen, it could be started for example with a minimum RC level of 10%. Such a level would ensure a balance between the desired quality of these RC products and the use of external recyclate (in other words more than just internally processed recyclate). Depending on the technological developments within the circular economy, this

[2] This includes all product categories as summarised in annex 4

arbitrarily imposed level could evolve dynamically.

In this proposal, we do not use the RC definition according to EN 14021, but we assume that internal recyclate, pre-consumer and post-consumer recyclates can all be taken into account to determine recycled content, as described in section 4.1. These recyclates, which originate from end-of-life products, have fully undergone at least one (mechanical) recycling process. Accepting all recyclate flows (internal, pre-consumer, post-consumer) in an RC product is important to have a sufficient base of producers, and does not affect the environmental objectives which are set by governments (avoiding waste from material recycling, reducing CO2-emissions, sustainable energy, etc.).
Accepting all material flows for the calculation of recycled content does not rule out that producers need to include these various types in the product composition. The various material flows always need to be traceable in the product itself and in product sheets.
Of course governments can always decide not to include certain recyclate flows when determining the recycled content of specific products.

In a Royal Decree pertaining to recycled content, it must be clearly indicated that biodegradable, compostable and oxo-degradable polymers cannot be used for the production of RC products. These polymers are excluded because if they are present, the stability of the complete polymer product cannot be guaranteed. To understand what is meant by biodegradable and compostable polymers, reference can be made to the Royal Decree of 9 September 2008 regarding product standards for compostable and biodegradable materials.

It is impossible to differentiate between virgin and recycled polymers using chemical analysis. The recycled content can only be determined using production data. The calculation sheet in annex makes it possible to calculate the RC with the data from the relevant producer, both for simple and composite products. These product data need to be traceable, and cannot relate to a one-off analysis. A company always needs to be able to guarantee this recycled content. This presupposes that the company in question can prove the origin of the used materials, and can also provide the necessary quality guarantees. Proving the recycled content of a product can also be done using a product or company certificate.

2. The RC product must comply with the applicable technical specifications and other quality requirements or legal obligations which are known or documented as such.
    a. The technical specifications and other quality requirements will always be product-specific requirements which are laid down in standards, specifications documents or technical sheets.
    b. The demonstrability of compliance relies on internal quality controls or on an external analysis report from an accredited laboratory. The controls or analyses must refer to the applicable production order or lot, and to the incorporated standards and specifications. Any analysis reports used must not be older than 1 year.
    c. The quality control results or analysis reports can be requested in the event of dispute.

3. The RC product must not be harmful to human health or to the environment.
    a. Specifically, this means that the RC product is REACH-compliant and that any applicable communication obligation is correct.
    b. If recyclates are used which were produced in Europe, then REACH compliance must be proven for the entire lot.

c. The demonstrability of REACH compliance is based on declarations/certificates from raw materials suppliers or from accredited laboratories, but can also be based on eco-labelling such as the European Eco-label, Oeko-Tex, Blauwe engel, etc. Any analysis reports, certificates or eco-label systems cannot be older than 1year.

If the product to be purchased is made up of various plastic components which can be easily disassembled or separated from each other, the previously mentioned criteria apply for the separate components in which plastics are processed.

In addition to the registration system of the producer itself, the demonstrability of various RC elements is based on certificates issued by third parties. The certification organisations who issue certificates naturally need to be accredited by the government in question.

6.3 Use of RC for eco-labelling.

The minimum conditions described above can also be used as an incentive for the possible use of RC within the European Ecolabel system.
Currently, RC is not a criterion among most products, but could possibly be applied if relevant and industrially feasible.
For certain components of PC computers, this has already been considered. (http://ec.europa.eu/environment/ecolabel/documents/personal.pdf). In response to this report, the European plastics association PlasticsEurope has formulated a number of considerations and reservations. (http://www.plasticseurope.org/documents/document/20130107153658-2012_10_03__plastics_industry_views_on_ecolabelling.pdf)

In the context of the potential use of RC for eco-labelling, we would like to indicate the relevance for the various Ecolabel categories in which polymer products (plastics, textile, composites and coatings), certain components or their packaging can be applicable.

Relevant	- textile for clothing - bed linen and interior textile - shoes - floor covering textile - mattresses
Not very/partly relevant	- devices* (6 product groups) - lubricants** - cleaning and hygiene** (8 product groups) - paints and varnish** - growing media and soil improvers**
Not relevant	- paper products (5 product groups) - tourist services (2 product groups) - toilets and urinals - taps and shower heads - floor covering (2 product groups)

*casing, ** packaging

6.4 Combining government tools

The **RC instrument can of course also be combined with other tools** which can be used by the government. Useful combinations are:

- Tradeable recycling certificates for certain collected materials and the recyclate content of products which are made with the recycled materials
- EPR for certain EOL products which are taken back and recycled (by themselves or by an organisation set up by producers) and the recyclate content of new products which are produced with recyclates.

The introduction or application of tradeable recycling certificates and EPRs are always regional or federal decisions which could potentially distort the market. Prior consultation with all the actors involved (government, recycling and production companies) is necessary.

For composite products made up of various materials with differing densities, for example in end-of-life vehicles and WEEE where the metal fraction (ferrous metal, non-ferrous metal and precious metals) is clearly more considerable in comparison with the lightweight and bulky plastics, it is important to give sufficient attention to plastics. Recycling and EPR objectives expressed in 'tonnages' are interesting for metals and ceramics, but for bulky and light materials such as plastics and textile, they are clearly a disadvantage. If the intention is to encourage plastics recycling, this disadvantage will have to be taken into account.

6.5 Research and prevention initiatives

In addition to this specific policy instrument to give useful applications to existing waste, various authorities can also **encourage and support the necessary research** as well as all **initiatives focused on preventing plastic waste**.

These initiatives are necessary to reduce the proportion of thermal recycling (incineration) of energy-rich plastic waste, or to limit the use of virgin material in new products.

Research into recycling and polymer RC products must focus primarily on:

- Purifying waste flows by removing impurities and the extraction of SVHC components and colourants. Pure and decoloured recyclates are usable in many more products.
- Improving the recyclability of plastic products by substituting SVHCs (although these are usually highly effective additives) with new materials, applying more high-performing polymers or improving the demountability of composite products.
- Making recyclates stable and compatible so that they can be more widely usable.
- Enhancing the chemical content in recyclates. In order to determine the value of a recyclate, only the polymer content is currently examined and not the presence of certain ingredients/additives which have a larger added value than commodity polymers.
- The energy-efficient reduction of thermosets, composites and rubbers. In order to be used more, energy and material consumption (knives, hammers, etc.) for reducing these materials needs to be decreased.
- Life Cycle Analysis (LCA) of RC products.

Preventive actions need to focus on:

- Training Eco-design/design for dismantling/design for recycling
- Cooperation between producers and recycling companies with regards to information exchange regarding the composition of products, dismantling and recycling
- Developing and promoting reusable packaging.

- Dematerialisation of plastic products. Many products contain more materials than are necessary to obtain the desired properties.
- Technological advice for companies to avoid waste.
- Raising awareness among consumers of the importance and value of plastics in society.

The results of both research projects and preventive actions can be used to periodically adjust objectives, as well as to refine the legislation for certain products.
It is important that regulations evolve at the same pace as new process and product developments. If the quality of RC products can be managed and guaranteed, and if it can be demonstrated that products with recyclate content comply with all applicable legislation and regulations, no RC products would need to be excluded on the basis of their recyclate content.
Examples:
- If it is possible to easily separate SVHC-containing plastics in WEEE or end-of-life vehicles from plastics which do not contain SVHCs, the applicable legislation or regulation can be adjusted to incorporate the risk-free plastic flow from WEEE or vehicles in various applications.
- If harmful plasticisers can be extracted from PVC in an economically-responsible manner, the PVC recovered in this way can also be used more widely in new products.
- In certain construction products, including high-pressure gas tubes, recyclates cannot be used in principle. If producers of virgin polymers, and compounds in which recyclate is processed, can demonstrate that there are absolutely no risks associated with the managed use of recyclate, the relevant product standards and legislation would have to be adjusted.

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Annex 2: Abbreviations

WEEE	Waste Electrical and Electronic Equipment (WEEE)
BDE	bromated diphenyl ether
BPF	British plastic federation (UK)
BSI	British standardisation institute (UK)
CLP	Classification, labelling and packaging
CEC	Central Economic Council
DTT	Dithiothreitol
EEA	Electric and Electronic Appliances
ELV	End of life vehicles
EMAS	eco-management and audit scheme
EOL	End of Life
EoW	end of waste
EPA	environmental protection agency (US)
EPRO	European plastic recycling organisation
EPS	expanded polystyreen
EUPC	European plastic converters
EuPET	European association unoriented PET-film
FPS	Federal Public Service
FR	fire retardant
HBCDD	Hexabromocyclododecane
HDPE	high density polyethyleen
IML	in mould labeling
ITO	indium tin oxide
JRC-IPTS	Joint Research center Institute for prospective technological studies
LCA	Life Cycle Analyses
LDPE	low density polyethyleen
LED	Light Emitting Diode
LEED	leadership energy and environmental design (US)
MFI	Melt flow index
MKB	milieu kwaliteitsbeheer (Environmental quality management)
NIR	Near Infrared
OEM	Original Equipment Manufacturer
OLED	Organic Light Emitting Diode
PA	Polyamide
PAH	Polycyclic Aromatic Hydrocarbon
PAS	Plastic action System (UK)
PBB	polybromated diphenyls
PBDE	polybromated diphenyl ether
PE	Polyethylene
PET	Polyethylene terephthalate (polyester)
PFOS	Perfluoro-octane sulfonate

POP	persistent organic pollutants
PO	polyolefines
PP	Polypropylene
PRE	plastic recyclers europe
PS	Polystyrene
PVC	Polyvinyl chloride
QA-CER	quality assurance of content and eco-data of recycled materials in polymeric products
RC	recycled content
REACH	Registration, evaluation and authorisation of chemicals
RFID	Radio frequency Identification
RIVM	Rijksinstituut voor volksgezondheid en milieu (Dutch National Institute for Public Health and the Environment)
RoHS	restriction on hazardous substances
R-PET	recycled PET
SUMMA	Steunpunt duurzaam materialenbeheer (VL) (Flemish Policy research centre - Sustainable Materials Management)
SVHC	Substances of Very High Conern
EPR	Extended Producer Responsibility
VKC	Vlaams kunststof centrum (Flemish Plastics Centre)
WEEE	waste of electric and electronic equipment (AEEA)
WPC	Wood plastics composites
WRAP	waste and resources action (UK)
XRF	X-ray fluorescence

Annex 3: Overview of standards

EN 12099	Plastics piping systems - Polyethylene piping materials and components. Determination of volatile content
EN 13430	Packaging- Requirements for packaging recoverable by material recycling
EN 13437	Packaging and material recycling - Criteria for recycling methods. Description of recycling processes and flow chart
EN 14020	Environmental labels and declarations - General principles
EN 14021	Environmental labels and declarations - Self-declared environmental claims (Type II environmental labelling)
EN 14024	Environmental labels and declarations - Type I environmental labelling -- Principles and procedures
EN 14025	Environmental labels and declarations - Type III environmental declarations - Principles and procedures
EN 15342	Plastics - Recycled plastics - Characterization of polystyrene (PS) recyclates
EN 15343	Plastics - Recycled plastics - Plastics recycling traceability and assessment of conformity and recycled content
EN 15344	Plastics - Recycled plastics - Characterization of polyethylene (PE) recyclates
EN 15345	Plastics - Recycled plastics - Characterization of polypropylene (PP) recyclates
EN 15346	Plastics - Recycled plastics - Characterization of poly(vinyl chloride) (PVC) recyclates
EN 15348	Plastics - Recycled plastics - Characterization of poly(ethylene terephthalate) (PET) recyclates
EN 15347	Plastics - Recycled Plastics - Characterization of plastics waste
EN ISO 1133	Plastics - Determination of the melt mass-flow rate (MFR) and the melt volume-flow rate (MVR) of thermoplastics
EN ISO 179-1	Plastics - Determination of Charpy impact properties - Part 1: Non-instrumented impact test
EN ISO 179-2	Plastics - Determination of Charpy impact properties - Part 2: Instrumented impact test
EN ISO 180	Plastics - Determination of Izod impact strength
EN ISO 306	Plastics - Thermoplastic materials - Determination of Vicat softening temperature (VST)
EN ISO 3451-1	Plastics - Determination of ash - Part 1: General methods
EN ISO 527-1	Plastics - Determination of tensile properties - Part 1: General principles
EN ISO 527-2	Plastics - Determination of tensile properties - Part 2: Test conditions for moulding and extrusion plastics
EN ISO 527-3	Plastics - Determination of tensile properties - Part 3: Test conditions for films and sheets
ISO 14001	Environmental Management (EMS)
ISO 14040	Environmental management - Life cycle assessment - Principles and

	framework
ISO 14043	Environmental management - Life cycle assessment - Life cycle interpretation
ISO 14044	Environmental management - Life cycle assessment - Requirements and guidelines
ISO 15270	Plastics - Guidelines for the recovery and recycling of plastics waste
ISO 17021	Conformity assessment - Requirements for bodies providing audit and certification of management systems - Part 1: Requirements
ISO 17025	General requirements for the competence of testing and calibration laboratories
ISO 20400	Sustainable procurement - Guidance
ISO 9001	Quality Management systems - Requirements

Annex 4: Analysis recycled content product categories

product category		Opportunity recyclate	Tolerance	Regional collection/sorting/processing	Relevance regional plastics industry	Relevance public procurement contracts	Usable technology
Packaging	Food	+[1]	-	+++	+	-	Film extrusion and blow moulding,
	Non-food	++	+	+++	+	-	
Building and construction		+++	+[3]	++[4]	+++	+++	Profile extrusion, sheet extrusion
Transport (automotive)		++	+[3]	-	++	++	Extrusion, injection moulding
Textiles (clothing, interior, technical)		++[2]	++	++	++	++	Fibre extrusion, spinning, non-woven
Outdoor (garden, street, container, agriculture)		+++	+++	++	+++	+++	Intrusion, injection moulding, film extrusion, sheet extrusion
Other (toys, office equipment, EEA, etc.)		+	++	++[5]	++	++	Injection moulding, extrusion, thermoforming

Table – relevant plastic product categories

[1]: primarily PET, PO
[2]: primarily PET (from packaging)
[3]: subject to standards
[4]: primarily PVC, (PE)
[5]: via recupel/container rigid plastics

Products which contain recycled plastics		
Highly tolerant regarding quality of the recyclate	**Moderately tolerant regarding quality of the recyclate**	**High-end regarding quality of the recyclate**
garden furniture	facade cladding	baby bottles
sound barriers	jerrycans	packaging non-food
covers for utility lines	PVC pipes	foil applications (mono-layer)
padding profiles	WPC materials	closed-loop food packaging
	Damping material for road and rail traffic	open-loop PET
	backings of fitted carpet	
	finishing profiles (non-visible)	
	flower pots	

Table - Products which contain recycled plastic

Annex 5: Example for the calculation of the recycled content of a composite product

For example, a local authority could decide to purchase portable plastic garden chairs, or issue a procurement contract to this end.

The specifications could lay down a number of technical aspects such as:

Colour of chairs: RAL colour ….
Various dimensions: sitting height, lumbar area height, minimum dimensions sitting area
Colour fastness and UV resistance
Bearing strength: stable up to 150kg load
For ergonomic reasons, maximum weight is set at 12kg
Foldable or stackable
Does not contain any harmful substances (REACH-compliant)

For all these technical aspects, specific norms can also be referred to.

To allow the market sufficient room for manoeuvre, the product composition will not be further established. All products which comply with the technical specifications mentioned above are eligible in principle. However, in addition to the price criteria, the importance of recycled materials can also be taken into account.

With this example, we want to show that the RC content of a composite product is not so easy to interpret. Indeed, a garden chair consists of a top part and a bottom part. The bottom part might consist of metal legs (steel or aluminium), wooden legs, or glass fibre-reinforced plastic legs. The top part might have a plastic shell, but might also be a metal or composite frame, in which coated textile is stretched.

Since all the materials used have a different density, these differences in density are very important for the calculation of the RC content, which can be calculated on the total product weight or on the plastic fraction. Using the calculation sheet (separate excel sheet), these effects can be highlighted (screenshots below).

Berekenen van de recycled content

Zuiver kunststof artikel			Basispolymeer	Polypropyleen				
			Intern recyclaat	Polycarbonaat				
			Pre-consumer recyclaat	Hoge Densteit Polyethyleen				
			Post-consumer recyclaat	Lage Densiteit Polyethyleen				
componenten								
	polymeer	intern recyclaat	Pre-consumer	Post-consumer	Additief 1	Additief 2	Additief 1 (recyclaat)	Additief 2 (recyclaat)
type	PP	PC	HDPE	LDPE	Decabroom	Koolstof	Zand	Glasvezel
densiteit	0,9	1,22	0,95	0,92	3,6	2,62	1,6	2,52
	Volumeprocent			Volumeprocent	Gewichtsprocent			
data	10	% virgin		60%	38%	recycled content op het totale artikel		
	15	% intern recyclaat		45%	28%	recycled content op het totale artikel exclusief intern recyclaat		
	20	% pre-consumer recyclaat		25%	17%	recycled content op het totale artikel enkel post-consumer		
	15	% post-consumer recyclaat		83%	85%	recycled content op de zuivere kunststoffractie		
	20	% additief 1		58%	55%	recycled content op de zuivere kunststoffractie exclusief intern recyclaat		
	10	% additief 2		25%	23%	recycled content op de zuivere kunststoffractie enkel post-consumer		
	10	% additief 1 (recyclaat)						
	0	% additief 2 (recyclaat)						
	100	som						

Berekenen van de recycled content

Samengesteld artikel			Basispolymeer	Polypropyleen						
			Intern recyclaat	Polystyreen						
			Pre-consumer recyclaat	Acrylonitrile Butadieen Styreen						
			Post-consumer recyclaat	Polypropyleen						
	polymeer	intern recyclaat	Pre-consumer	Post-consumer	additief1	additief 2	additief 1 (recyclaat)	additief 2 (recyclaat)	metaal component	hout component
type	PP	PS	ABS	PP	Krijt	Talk	Krijt	Talk	Inox	Hardhout
densiteit	0,9	1,05	1,05	0,9	2,5	2,7	2,5	2,7	7,9	0,85
	Volume procent			Volumeprocent	Gewichtsprocent					
data	50	% virgin		15%	4%	recycled content op het totale artikel				
	5	% intern recyclaat		10%	3%	recycled content op het totale artikel exclusief intern recyclaat				
	5	% pre-consumer		5%	1%	recycled content op het totale artikel enkel post consumer				
	5	%post consumer		23%	25%	recycled content op de kunststoffractie				
	0	% additief 1		15%	16%	recycled content op de kunststoffractie exclusief intern recyclaat				
	0	% additief 2		8%	8%	recycled content op de kunststoffractie enkel post-consumer				
	0	% additief 1 (recyclaat)								
	0	% additief 2 (recyclaat)								
	35	% metaal								
	0	% hout								
	100	som								

Screenshots calculation recycled content