National Institute for Public Health
and the Environment
Ministry of Health, Welfare and Sport

Waste handling and REACH

Recycling of materials containing SVHCs:
daily practice challenges

RIVM Letter report 2016-0159

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This investigation has been performed by order and for the account of Ministry of Infrastructure and Environment, within the framework of REACH

This is a publication of:
National Institute for Public Health and the Environment
P.O. Box 1 | 3720 BA Bilthoven
The Netherlands
www.rivm.nl/en

Synopsis

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To achieve a circular economy it is essential to recycle substances, materials and products created by that economy. Recycling, however, becomes more difficult when said materials and products contain substances that are so hazardous that their use is restricted. This is the case with any substance that is identified under the REACH Regulation as a 'substance of very high concern' (SVHC). Products containing SVHCs can only be used when their use is specifically authorised. Producers are concerned that their recycling practices and the use of recycled waste will become more difficult if the waste contains SVHCs.

This was the conclusion drawn from a series of interviews with producers and sector organisations about bottlenecks, and possible solutions, conducted by RIVM. One challenge facing parties involved in the responsible reuse of waste is the current uncertainty surrounding the boundaries of the Waste Framework Directive and those of REACH: when does waste become a substance, a mixture or an article? Under REACH, permission for the safe use must be obtained; this requires significant information to be provided on the composition of the material, information that is often not available in great detail. There is still a lot of uncertainty about the SVHCs present in waste streams, potential future SVHCs and exactly when permission for safe use should be applied for.

The companies interviewed also stressed how essential it was to separate waste which contains SVHCs from SVHC-free waste streams in an early phase of the waste recycling process, a practice which also requires detailed knowledge of the SVHCs present in waste. The companies indicate that regulatory or financial incentives may be needed to stimulate the implementation of separation processes that are less economically feasible.

Finally, it's very important to develop applications in which recycled material containing SVHCs can be used safely. One example hereof is the three-layered sandwich PVC tube which has a middle layer containing SVHCs but two outer layers made from SVHC-free material which protects humans and the environment from any risk of exposure.

Keywords: REACH, SVHCs, recycling, waste, waste chain, plastics, PVC, Waste Framework Directive, circular economy

Publiekssamenvatting

Afvalverwerking en REACH.
Recycling van materialen die SVHC's bevatten: uitdagingen in de praktijk

Het hergebruik van stoffen, materialen en producten is belangrijk om een circulaire economie te bereiken. Dit wordt echter bemoeilijkt wanneer materialen en producten stoffen bevatten die zo schadelijk zijn dat het op Europees niveau gewenst is om ze geleidelijk aan niet meer te gebruiken (uitfaseren). Dit is het geval bij stoffen die binnen de Europese stoffenwetgeving REACH getypeerd zijn als zeer zorgwekkend (Substances of Very High Concern, SVHC). Deze stoffen mogen op den duur alleen nog worden gebruikt als daar specifiek toestemming voor is verleend. Producenten die afval hergebruiken denken hierdoor in de problemen te komen wanneer hun producten deze stoffen bevatten.

Dit blijkt uit een interviewronde van het RIVM langs producenten en brancheorganisaties over knelpunten en mogelijke oplossingen. Het grootste probleem is de onduidelijkheid wanneer een materiaal onder de afvalwetgeving valt of onder REACH: wanneer wordt afval een stof, mengsel of artikel? Volgens de afvalwetgeving moet het materiaal worden vernietigd als het hoge concentraties schadelijke stoffen bevat. Volgens REACH moet toestemming worden gevraagd voor veilig gebruik. Dit laatste vergt veel kennis over de stoffen, die nog vaak ontbreekt. Daarnaast bestaan er onduidelijkheden over welke SVHC-stoffen in huidige afvalstromen zitten, welke stoffen in het afval in de toekomst als SVHC zullen worden bestempeld, en wanneer voor de nu geïdentificeerde SVHC’s toestemming moet worden gevraagd.

Om ervoor te zorgen dat schoon afval niet vermengd raakt met vervuild afval, is het volgens de geïnterviewde bedrijven belangrijk dat de SVHCs in een vroege fase van de afvalverwerking worden gescheiden van de rest van het afval. Ook hier is kennis van belang om welke stoffen het gaat en waar ze in zitten. Daarnaast zijn volgens hen juridische en economische prikkels gewenst die stimuleren dat ook minder winstgevende scheidingsprocessen worden uitgevoerd.

Verder is het belangrijk om voor gerecycled materiaal dat SVHC’s bevat, toepassingen te bedenken die zodanig zijn ontworpen dat de producenten en gebruikers niet aan deze stoffen worden blootgesteld. Op deze manier kunnen de stoffen ook niet in het milieu terechtkomen. Een voorbeeld zijn drielaags pvc-buizen waarbij de binnenste en buitenste laag SVHC-vrij zijn en de SVHC in de middelste, afgeschermde, laag zit.

Kernwoorden: REACH, afval, circulaire economie, zeer zorgwekkende stoffen, kunststof, plastic, PVC, recycling

Contents

Summary

Circular economy may enhance recycling and thus result in higher percentages of recycling. This ambition may conflict with an aim to prevent adverse environmental and human health impacts. These potential conflicts may arise during the waste stage, under the Waste Framework Directive, and under the REACH Regulation when recycled material is brought on the market again.

The present study investigates the challenges encountered by various stakeholders active within the waste chain recycling plastics or applying recyclates, by means of a number of interviews. The results from the interviews are complemented with literature data on the plastic waste chain. The study shows that most companies are active in European or international networks where waste material, either raw or already treated, is further treated and finally recovered or disposed of.

The material is often available as a heterogeneous mass which may originate from different sources such as electronics, packaging material, agricultural sources or end-of-life vehicles. The material suitable for recycling is sorted, grinded, washed and finally compounded into new secondary material consisting of one polymer. Origin of the waste material may still be traceable in the beginning of the chain, but becomes less clear after one or two treatment steps.

The interviews revealed that there are quality criteria for impurities in recyclates. Although agricultural chemicals and hazardous materials are mentioned under prohibited materials in the guidance for plastic scrap, the interviews revealed that main attention goes to other polymers or to other materials such as wood, rubber, cork, staples, which can be recognised by sight. For quality reasons these should be below 2%.

Certain activities, such as measuring, sorting or labelling may enhance the separation into waste streams with so-called Substances of Very High Concern under the REACH regulation, but application may be limited because of practical considerations. In the beginning of the chain material is very heterogeneous, from the outside it is often not clear whether the material contains substances of very high concern and instant and on-site measurements are often not feasible. However, to keep the waste streams for recycling as 'clean' as possible sorting SVHC containing material, or keeping SVHC rich waste streams separate, should take place in the beginning of the chain.

The report summarizes a number of solutions to address some of the challenges encountered, and proposes to have a discussion on the balance between keeping exposure as low as possible, the practical implications of removing or destroying the substances of very high concern (SVHCs) already present in the technosphere and the cost-benefits of the various solutions. Thus, such a discussion should include the cost and benefits of circularity of the material containing the SVHCs, the costs and benefits of removing the SVHCs from the waste stream and ensure a high level of protection of man and environment.

1 Introduction

1.1 Circular economy and depletion of natural resources as a main driver for recycling

On December 2015, the European Commission published a communication on circular economy entitled 'Closing the loop - An EU action plan for the Circular Economy'. In that communication, the Commission indicated actions that had been launched to ensure a better implementation of the waste legislation, including separate waste collection, and to raise awareness at national level. Plastics were recognized as one of the priority areas and it was recognized that hazardous additives[1], so-called legacy substances, may pose technical difficulties in recycling (COM, 2015). This issue was earlier recognized by various Member States and brought forward by the Dutch authorities in the meeting of the Competent Authorities for REACH and CLP (CARACAL) of February 2013, as indicated in Annex 1 of this report (CARACAL, 2013).

At the end of their life cycle, articles[2] become waste, which can be processed in various ways. Waste can be disposed off by landfilling, by incineration, or by recycling leading to products that can be marketed again. Waste is preferably handled along the so-called waste hierarchy, in order of decreasing preference: prevention (of the generation of waste), reuse, recycling, incineration (with energy recovery) and disposal (landfill). From a resource efficiency point of view, reuse and recycling are preferred over energy recovery and landfill. For sustainability reasons and to decrease the dependency of recyclers of suppliers from outside Europe, there is a strong drive to close material loops and to come to a circular economy where waste is processed and the valuable constituents are brought on the market again (COM, 2015). Europe has set targets for the recycling of for instance for municipal waste and packaging of 65% and 75% for 2030 respectively (COM, 2016).

When material is being recycled it may be subject to different legislative regimes. Until the so-called "End-of-Waste" (EoW) is reached, material is defined as waste, which is regulated by the Waste Framework Directive (2002/68/EC). When the EoW criteria are fulfilled, the waste material ceases to be waste and is covered by the REACH Regulation or by other legislation regulating the marketing of products, for instance the RoHS Directive or the Toys Directive.
According to Article 6.1.d of the Waste Framework Directive the risks of the various waste disposal options, including the risks of reuse or recycling, should not lead to overall adverse environmental or human

[1] The word 'additive' is used in various places in this report and is considered to be a substance added to polymers in small quantities to improve or preserve it. There are various kinds of additives.
[2] REACH distinguishes substances, mixtures and articles, whereas the Waste Framework Directive is handling about substances or objects. In this report 'article' is being used to refer to both articles under REACH and objects under the Waste Framework Directive.

health impacts. REACH and several sectoral legislations, such as the Toys Directive and the RoHS Directive, contain similar statements.

Additives have often been applied to a certain material to increase the performance. However, such substances may pose a challenge for the waste treatment of such material when these substances are classified as hazardous. The waste material may be classified as hazardous as well if the substance is present in substantial amounts (often above the 0.1% or above the 0.3% limit), which implies restrictions on transport and on waste handling; only treatment methods described under the Basel Convention apply in these cases.
The ambition to recycle as much material as possible may conflict with aim to prevent adverse environmental and human health impacts. At the waste stage, identifying waste as hazardous limits the number of waste-regeneration options as prescribed by the Basel Convention. At the stage of bringing secondary raw material on the market requirements under REACH or other product legislations may introduce limitations due to the concentrations of hazardous substances, like Persistent Organic Pollutants (POPs) or SVHCs[3], still present. Aspects about the Dutch ZZS substances and waste treatment are mentioned in the discussion section of this report

The present study focuses on the watershed between waste policy including recycling targets and the REACH Regulation. Both legislations aim to protect human health and the environment, which is often translated in the objective to remove hazardous substances such as SVHCs from the technosphere as much as possible.
The present study made use of in depth interviews with sector organisations and recycling companies to:

1. identify the challenges with regard to waste management of plastic materials or articles potentially containing SVHC's,
2. prepare an inventory of sectors and types of materials (or articles) where the recycling plastics that may contain SVHCs is currently an issue,
3. identify possible ways to address the challenges for recycling of plastics based on the present ideas about waste treatment and chemicals policy,
4. make an inventory of current idea's and ongoing initiatives that have been implemented already addressing (some of) the identified challenges with a main focus on SVHCs and POPs.

1.2 Stakeholder selection

The present study focused on the challenges identified in the field by recycling companies and associations. To obtain a more general insight on material recycling and the challenges faced by the sector, six representatives from six different associations were interviewed. These associations comprised:

- the trade association of certified automobile, motorcycle , truck and related vehicle dismantlers STIBA,
- the Dutch Federation of Rubber and Plastics Industry NRK,

[3] SVHC = substance of very high concern as defined under the REACH regulation. Basically, the challenges described in this document also apply to so-called persistent organic pollutants (POPs).

- the organisation for plastic pipe systems in the Netherlands BureauLeiding,
- the Trade association Employers Metal –Elektro FME,
- the European manufacturers of Expanded PolyStyrene EUMEPS, and
- Waste Management Association Vereniging Afvalbedrijven.

From the results of these interviews, six companies were selected covering the different roles in the value chain of plastic waste recovery, i.e. a car dismantler, a shredding company, a recycling company and a company applying the recycled material into new products. The interviews of this second tier aimed to provide an overview of the daily practice of recycling, challenges in dealing with SVHC containing materials and to get insight in possible solutions. Additionally, literature sources were consulted to complement the interviews.

In this second tier of in depth interviews, further focus was applied on polymer recycling and not on metal recycling. This focus was chosen because the results from the first tier suggested that especially the polymer recycling industry is currently facing challenges with regard to the handling of waste possibly containing hazardous substances of which SVHCs. Furthermore, to maximize obtaining insight in the challenges faced and possible solutions, companies that recognized the identified problems and had found solutions got priority in the tier 2 in depth interviews. In most cases these turned out to be companies recycling long-life polymers.

2 Characterisation of the waste treatment sector for plastics

Waste is processed in the form of various waste streams and can be treated in several ways. In order to identify the challenges related to handling SVHCs in the various waste treatment processes it is necessary to know which waste streams can be distinguished, how these streams are being processed and where possible measures can be taken to address the challenges encountered. This chapter therefore starts with a description of the Dutch waste treatment sector in general and various aspects that may be important in relation to SVHCs present in the waste streams. The chapter starts with a general description of polymer recycling (2.1), the companies interviewed (2.2) and the fact that the companies are active within an international network (2.3). The subsequent parts focus on waste collection and sorting to polymer (2.4), the type of polymers recycled (2.5), sorting out and destination of the recyclates (2.6). The chapter finishes with quality control and composition (2.7), application of the End-of-Waste criteria (2.8) and transport (2.9).

2.1 The waste chain

Plastic waste may be treated along three different routes: incineration with energy recovery, recycling and landfilling[4]. Figure 1 provides the simplified scheme for thermoplast polymer recycling. Waste is being collected and sorted, followed by grinding, compounding and moulding/extrusion, which finally results in a new product. In the first stages the mixed waste is sorted, washed and dried and grinded to a requested size after which the scrap can be used as feedstock in compounding. In the compounding stage all kinds of additives can be added depending on the specifications of the client and the technical qualifications needed. The output may be in the form of pellets or granules, which have to comply to a certain purity and specific physical properties. Finally, the recyclate is being moulded into a final form (the article). From the compounding stage onwards, the route of processing for virgin and recycled material are similar. Thermoset polymers, such as polyester and polyurethane, cannot be recycled this way as they do not melt, but degrade when heated (Jetten, 2014), see also 2.5.

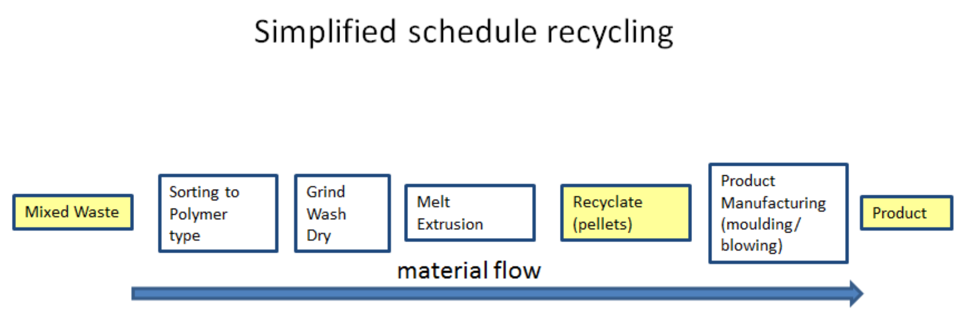

Figure 1. Simplified scheme of the thermoplast polymer recycling chain

[4] Landfilling of plastic waste does not take place in the Netherlands.

The recycling may start with different types of waste. There are several possibilities to categorize various types of waste according to their origin. Categorisation based on Municipal, Industrial and Agricultural waste is a very common one. With the focus on plastic, here, the categorisation proposed by Plastics Europe (2015) is adopted. Consequently, the categories distinguished in the present study involve packaging, building and construction, automotive, electrical and electronics, agriculture and 'others'. The category 'others' include sectors such as household (toys, leisure and sports goods), furniture and medical devices. A good description of the plastic packaging waste from households in the Netherlands is provided in ILT (2011).

2.2 Companies interviewed

A representation of the stakeholders interviewed in the various waste chains is provided in Figure 1. Seven companies were interviewed. The companies interviewed handled different kinds of waste and are active in one or more parts of the waste chain. Companies mainly active in a single chain were ARN Recycling BV and Coolrec/PHB, active in automotive and electronic waste respectively (Table 1).

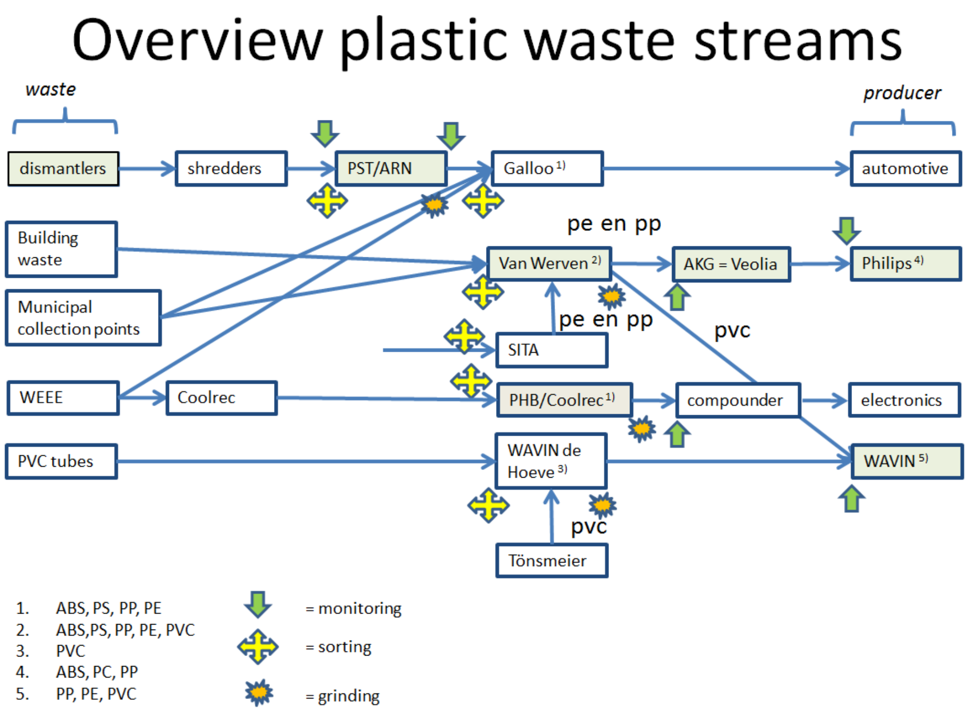

Figure 2. Overview of the companies interviewed (in grey) and their position in the plastic waste streams investigated. Not incorporated are the waste streams: agriculture, packaging, others

Other companies were active in various waste streams like Van Werven and Veolia Polymers (previously AKG). These companies may be connected to other companies, either through buying bales of homogeneous polymer or through selling material to a third company that treats the material further or disposes of it. All companies interviewed are private companies. In a number of the cases the company was a subsidiary of a larger company.

In the case of WAVIN, this company started in the '50s as part of Drinking water company Overijssel to replace the cast iron drinking water pipes, that showed too many leakages, by a PVC system. At the moment, WAVIN is a private company. Bureauleiding facilitates the Dutch plastic pipe collection scheme BIS (Buizen Inzamel Systeem) since 1991[5] that collects the waste PVC pipes. Besides these pipes, BIS also collects PP and PE pipes. BIS is fully funded by industry, among which by WAVIN[6]. ARN Recycling BV started as a company in the 1990s in order to organise the recycling of end-of-life vehicles. Stakeholders are the RAI Vereniging, BOVAG, FOCWA and STIBA. Although not a stakeholder, the Dutch state took part in founding ARN as well. ARN Recycling BV is at least partly subsidised by a €45 deposit paid on each new car[7]. For packaging material there is a similar organisation through which the municipalities are paid for their packaging waste (Afvalfonds Verpakkingen, 2017).

Table 1. Origin of waste from the various stakeholders interviewed in percentages

origin	municipal waste	municipal collection points	building material	industrial waste	ELV	WEEE	pipes
Kind of material	mix	mix	mix	mix	mix	mix	PVC
ARN Recycling BV a)	-	-		-	80		
Van Werven (PVC) b)	-	30	50	5	-	-	5
BureauLeiding/WAVIN c)	-	-	-	-	-	-	100
Coolrec/PHB d)	-	20	-	-	-	80	-
Veolia Polymers/ AKG	60-70	10-30	-	10	-	-	-

a) ARN receives shredded material from shredder companies under the waste codes for light shredder residue (19104) and heavy shredder residue (191006), assumed is 80% ELV and 20% other shredder material. Minor amount consists of WEEE as only Weelabex certified companies are allowed to treat WEEE.

b) Of its PVC, Van Werven receives 50% from building material, 30% from municipal collection points, 5% pipes through BureauLeiding/BIS and 5% industrial waste is post-industrial waste. Of the remaining 10% van Werven receives 5% through demolishers (greenhouse waste), and 5% construction waste.

c) WAVIN receives its recycled PVC material from Van Werven

d) Coolrec/PHB mainly recycles rigid thermoplasts from municipal collection points, refrigerators and electronics.

2.3 International market

The interviewees indicated that the recycling business is not confined to the Netherlands, but that it is an international market where Dutch companies have subsidiaries in other European countries or where they are part of a company with the head office abroad. Examples are Van Werven with locations being active in Belgium and the UK, Veolia Polymers, which has its headquarters in France. Plastic Herbewerking Brabant BV (PHB) is a subsidiary of Coolrec, which has locations in

[5] http://www.bureauleiding.nl/BIS/
[6] Members of BureauLeiding are WAVIN, Pipelife, Dyka Alphacan and Martens group
[7] These activities are being paid from a €45 payment at the purchase of a new car http://www.arn.nl/recycling/recycling-van-autos/

Belgium, Germany, France and the Netherlands, and is itself a part of the Van Gansewinkel Group. A similar setup holds for companies such as Sita Recycling and Stena.

This international orientation is also found in the waste streams that are partly originating from the Netherlands and partly from abroad, with the same being true for the materials brought onto the market again. A few examples: Van Werven receives about 40% of the material from the Netherlands and 60% from abroad among which PVC material from Denmark. WAVIN got a part of the PVC waste from the German company Tönsmeier in the past. ARN sells part of its material to the French company Galloo, whereas 2/3rd of the material recycled by Van Werven goes abroad. Galloo, in the North of France, also receives shredder material from other European countries, such as Norway and Belgium, as is shown from EVOA notification documents for transboundary movements/ shipments of waste.

The interviewees furthermore indicated that Dutch waste recycling companies operate within a 1000 km radius of material transportation. The economically viable transport distance for a specific material is affected by the materials' type. For example, for expanded polystyrene (EPS), it was indicated that the economic transport distance is less than 100 km because the material is very light and bulky. For transport of waste EPS from a waste site to a waste treatment location this may be a problem if no compaction of the material takes place (Albrecht & Switalla, 2014). Transportation costs are indicted by the interviewees as a major component in EPS recycling and recycling of plastic waste more in general.

Conclusion: when looking for solutions to challenges of handling potentially SVHC containing waste, one may need to accept the international nature of the waste recycling market and hence look across borders.

2.4 Waste collection and sorting to polymer

The interviews showed that waste streams treated may vary considerably. Some waste streams, such as the PVC pipes, are very uniform in composition and the material life time being long cyclic. Municipal waste on the other hand is much more variable in composition and contains material with a very short product cycle.
The various players in the waste chain have their own niche market (see Figure 2). Companies in the beginning of the chain dismantle end-of-life vehicles or electronics and may send the plastic waste or a mixed fraction to another company for further treatment. Examples are the shredder companies which send their shredder fraction to ARN recycling BV or to Coolrec Nederland BV that send the plastic fraction to Plastic Herbewerking Brabant (PHB) after dismantling the electronics. Other companies, such as Veolia Polymers, SITA and Van Werven may receive plastic waste from municipal collection points or from building-waste companies. These companies may collect the waste, wash and dry it and sort it to different polymer type and finally grind it to the size requested by a client further down the waste chain. This may be the end user,

making the final product out of the scrap or a compounder compounding the scrap into pellets according to the specifications of an end user.

Except for the automotive waste, most plastics are selected by hand sorting or hand picking in the companies interviewed. In this process plastics are sorted by polymer type. Further sorting may take place by eddy current for removing remaining metals, density separation by air tabling or floating and vibration techniques (ARN Recycling, PHB). Homogeneous plastic waste streams, such as bottles, can alternatively be separated automatically into different polymer fractions using infrared spectrometry, vision colour sensors, X ray spectrometry and near infrared spectrometry. Some interviewees, however, indicated that mechanical recycling of a specific type of polymer may be difficult due to the variation in waste and the variable amount of fillers and additives present in different fractions of that one polymer. These fillers may result in different polymers having comparable density, thus complicating mechanical sorting. Another problem may be the black colour of the plastics. Garden furniture was provided as an example hereof. None of the interviewees indicated they specifically sorted waste on the possible presence of SVHCs.

2.5 Type of polymers recycled, volume and cost-benefit

Most companies interviewed handled between 40.000 and 60.000 tonnes of waste per year. The polymer type that is recycled is determined by the technical recycling possibilities, the market demand for the recyclates and the cost-benefit of recycling from the recycling company's perspective. Most of the interviewees recycled only rigid plastics or thermoplasts: ABS (Acrylonitrile butadiene styrene), PE (Polyethylene), PP (Polypropylene) and PS (Polystyrene) and to lesser extent rigid PVC. Certain other thermoplasts such as PET (Polyethylene terephthalate) are also recycled, but the volumes are much smaller. Thermoset materials such as polyester, polyurethanes and polyimides are hardly recycled to date because the material will burn or decompose upon heating[8]. Composites are also difficult to recycle because it is very difficult to separate the fibers and resin of which the composite plastics are composed (Jetten, 2014). Van Werven furthermore specifies that plastic foils are too complicated in composition and plastic from Plastic Heroes too diverse and too difficult to recycle. The interviewees indicated that there were specific companies recycling foils that were not among the companies selected for the study reported here. Rigid PVC is recycled by a few companies. BureauLeiding takes an important role in collection of PVC pipes. Until 2015 WAVIN recycled PVC pipes at their site De Hoeve in Hardenberg, but now receives recycled PVC from Van Werven. The recycled material is used by WAVIN to produce PVC pipes with recyclate. ARN Recycling BV mainly treats shredder material from end-of-life vehicles and PHB mainly WEEE. A large part of the packaging plastics from municipalities (69% of the municipalities) is being treated by SITA in Rotterdam, where about 10% is incinerated and the remaining part, mainly PE, PP, PET, foil and MIX is being recycled. A

[8] Wikipedia: Thermoset materials are generally stronger than thermoplastic materials due to this three-dimensional network of bonds (cross-linking), and are also better suited to high-temperature applications up to the decomposition temperature. However, they are more brittle. Since their shape is permanent, they tend not to be recyclable as a source for newly made plastic.

description is provided in Tauw (2016). SITA was not incorporated in the interviews.
The interviews showed that each company has its specific expertise, but also indicated that companies continue to look for opportunities to have their business case run, e.g. by upgrading their selection techniques and thus delivering higher quality products. However, there is a balance between the costs of upgrading and the benefits by selling more pure and more expensive recyclate. Partly these developments are market-driven. An important condition for these developments is the volume of the waste stream considered. If the amount of polymer to be sorted out is too small without a client paying for it, it will not work.

2.6 Sorting out and destination of recyclate

Within the waste chain the character of the material changes from raw waste material, e.g. mixed household waste, to pure grinded polymer at the end of the chain, if possible. Sorting out of raw waste material into waste streams consisting of material composed of one polymer takes place in the beginning of the waste chain (see Figure 1). After grinding, this material, it is mixed with similar grinded polymer from other sources or waste streams. Reaching that stage, it may be difficult to trace back the origin of the grinded material (see Figure 2), as it may originate from each of the categories mentioned in paragraph 2.1. Conclusion is that when the ambition is to keep the waste streams for recycling as 'clean' as possible sorting SVHC containing material should take place in the beginning of the chain.

The secondary material produced by the interviewed companies goes mainly to the automotive sector and to electronics manufacturers. Recycled PVC is used again to produce PVC pipes used for non-pressurized systems such as sewer systems, infiltration pipes and cable ducts. Recycled PVC is not applied in the drinking water sector because of both legal and technical reasons. Galloo indicates on its website that most material goes into automotive and that the remaining part goes to the building sector and the agricultural sector.

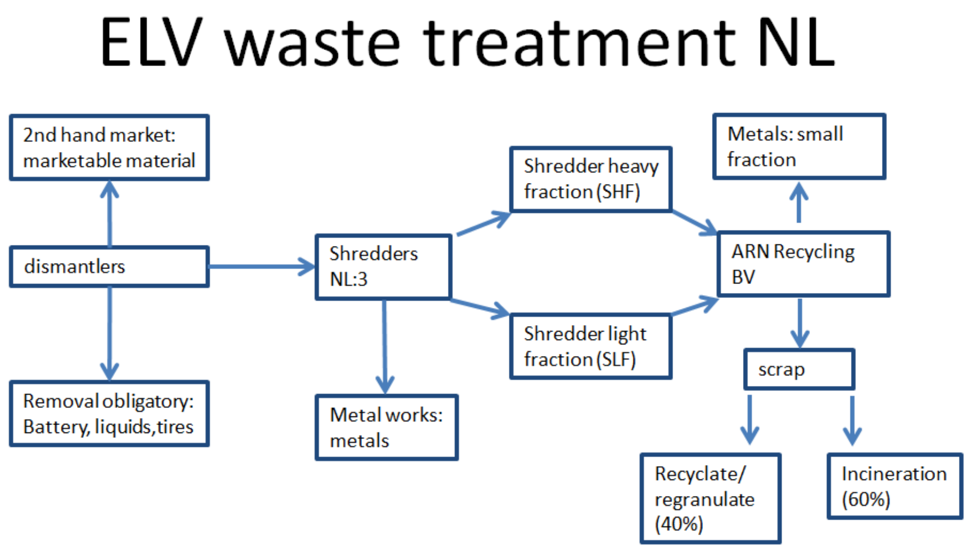

Figure 3. The ELV waste chain in the Netherlands

In the ELV waste chain, the vehicles are first treated by the car dismantlers who have the obligation to remove certain material, such as the battery, liquids, airbags and the tyres. A complete list of parts to be removed is provided in a publication of the Ministry of Infrastructure and the Environment (2012). They may also remove parts that still can be sold second hand, such as the starter, the dynamo and the lamps. After that, the vehicles are shredded. The shredded metals, iron, copper and aluminium are transported to metal handling companies, whereas the other shredder material, so-called shredder light fraction and shredder heavy fraction (SLF and SHF) are transported to the Post Shredder Technology (PST) of ARN. ARN sorts out the material into two or three weight fractions of plastics that are sold to a company further in the chain (Figure 3). This company divides the weight fraction into different polymer fractions. ELV waste material in other European countries is handled in a similar way, although outside NL the SLF and SHF-shredder fractions often end up in an incinerator (see for instance COWI, 2013). This is confirmed in Norden (2014) where is stated that "*SMED estimates the amount of plastic waste from ELV to 18 Kt with nothing recycled as most plastic ends in the "shredder light fraction" normally energy recovered. The segment comprises also trucks, caravans etc., but these kinds of vehicles are often exported for reuse.*" In contrast, Norden (2014) also indicate that the estimated amount of WEEE is 34 Kt "of which 1 Kt was recycled in Sweden and 14 Kt exported for recycling. This means a recycling rate of 44% (delivered amounts)." Also waste notifications from Norway indicate that also such WEEE-fractions may be marketed (see for instance notifications with 'shredded plastics from electronic equipment, mainly PS/ABS from TV's', EURAL code 19 12 04).

WAVIN is an end user handling mainly PVC pipes. The recycled PVC was until 2015 retrieved from "WAVIN De Hoeve", the waste division of the company, but at present from recycling company Van Werven. Van Werven may have obtained the raw material from building waste (e.g. PVC window frames or PVC pipes) or from municipal collection points (See Table 1). Van Werven sorts out the material from a mixed waste stream by hand. The sorting, washing and grinding finally result in 50 different products. On request speciality products with specific colour or size can be delivered.
A third example is Philips, which uses recycled polycarbonate (PC) in irons and recycled polypropylene (PP) in vacuum cleaners. Part of this material is delivered by Veolia Polymers, which gets also material from Van Werven recycling. Van Werven sorts out plastics from municipal collection points and from building waste, but also gets sorted material from SITA.

Various interviewees indicated that part of the waste that is collected still goes to an incinerator. ARN Recycling indicated that in the past SLF and SHF were all incinerated. Nowadays, 40% is recycled. The remaining 60%, of which 20% in the so-called fibre fraction, is not marketable and is incinerated. ARN Recycling BV referred to the European recycling targets for ELVs and indicated that these aim at 95% recycling including 10% energy recovery. Van Werven indicated that approximately 3% of the material they receive cannot be recycled. The material is transported to a waste incinerator, except for a mixed waste stream with PVC which is landfilled. It can be assumed that both the recycling targets, as well as cost-benefit considerations of the companies are reason to keep the fraction incinerated or landfilled as low as possible. Material may be incinerated in a waste incineration plant (AVI) or in a cement kiln, but costs are considerable.

2.7 Quality control and material composition

Throughout the waste chain, the plastics are sorted into different plastic fractions, ending up in secondary material consisting of one polymer. Though, the exact composition is unknown as long as no measurements are carried out.
Most interviewees have long term contracts on receiving and delivering material. In the beginning of the waste chain, quality control is carried out by eye. The waste should be delivered conform contract and the specifications provided. Companies handling single streams of polymer, e.g. those receiving scrap, grinding, compounding and moulding indicate that the first priority is that the material does not contain impurities in terms of other polymers or other materials. The interviews indicated that the end users determine the specifications of the polymer that is delivered. These specifications consider the type of plastic, the amount of contamination in terms of other plastics, the presence of other materials such as wood or cork or rubber and the physical characteristics. Depending on the type of end product, the presence or the amount of SVHCs may also be specified. Philips for instance, requests that the material delivered does not contain SVHCs. The latter suggests that somewhere in the chain, those substances need to be measured in the waste stream. The interviewees indicate that in most cases this happens at the end of the waste chain in the grinded material or in the pellets after compounding (Figure 2). As a consequence, part of the substances in the plastic waste, potential SVHCs, may end up in new mixtures and articles. This may be illustrated by imaging part of a certain SVHC in the SHF and LHF fractions in Figure 3 end up in the recyclate/regranulate fraction and part in the incineration fraction.

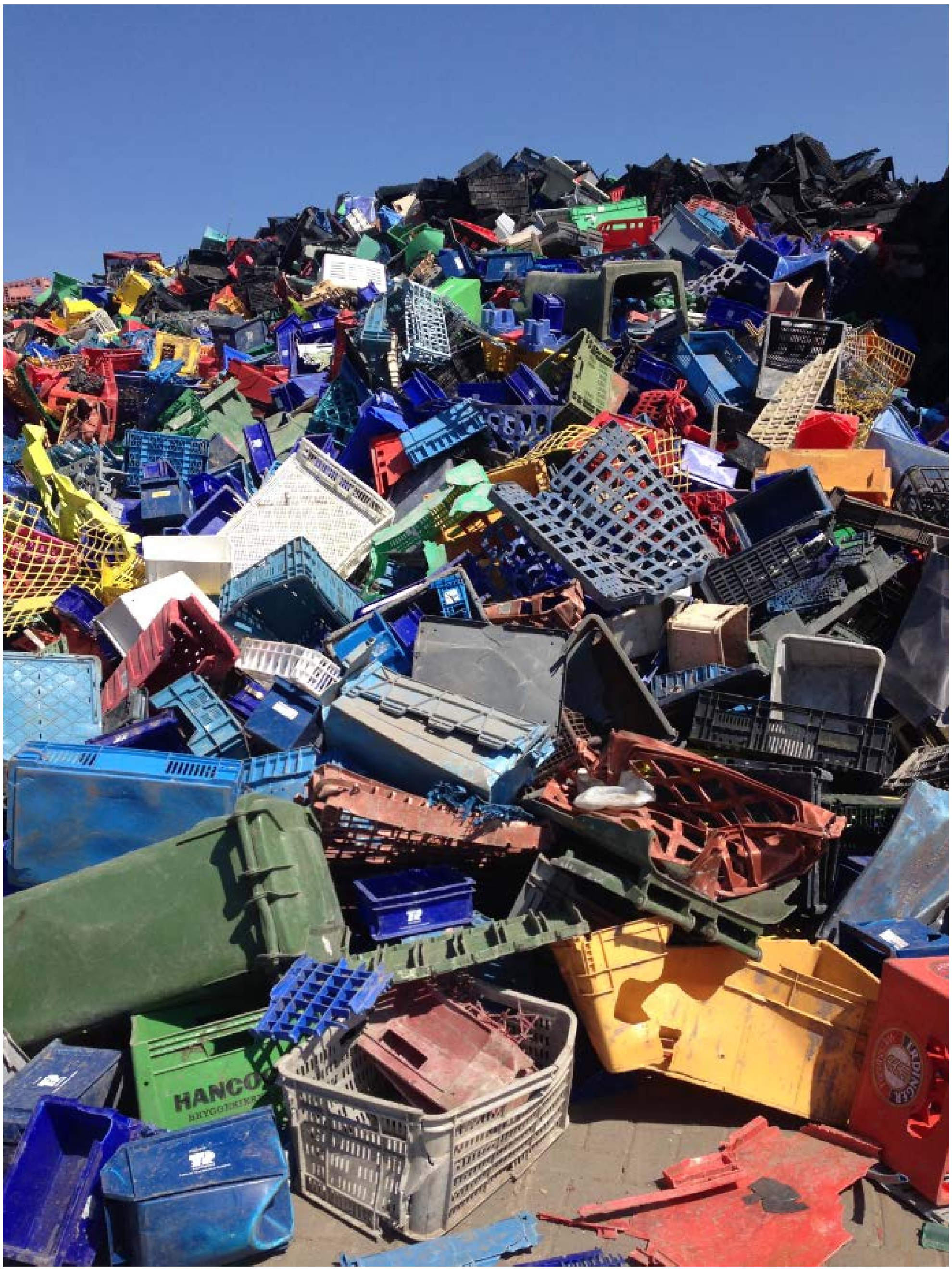

Figure 4. Plastic waste from municipal collection points to be processed at the site of a Dutch recycling company

Measurements may also take place earlier in the waste chain. Some of the interviewees (ARN Recycling BV and PHB-Coolrec) indicated that occasionally they carry out measurements on individual items. However, they also indicate that carrying out such measurements is a hurdle as the waste delivered is too variable with regard to kind of material and age (e.g. ABS from a car dashboard may contain other substances than ABS from electronics and old electric wires may contain other substances than recent ones). The already preselected waste from a municipal collection points in Figure 4 show some of the variability. Furthermore, they indicated that there are no agreements on who carries the costs of measurement, and there are no direct revenues coupled to conducting measurements.

Most companies however are well aware of the composition and the quality of the material they get delivered in a general sense. Material that consists of only ELV shredder has a more homogeneous composition than material which originates from ELVs mixed with electronic waste. Various interviewees indicated that batches not matching the quality criteria may be returned to the company that delivered it. One company indicated that BDE concentration in their outgoing material is decreasing and is currently below the limits that would define the material as POP waste (annex IV, POP Regulation). Various interviewees mentioned the limit of 2% impurities in the material they accept or deliver. This limit does not appear in European chemicals legislation, but is described in the international code by the Institute of Scrap Recycling Industries Inc (ISRI, 2016) and refers to other materials. ISRI (2016) indicates that quality of the baled plastic is the primary factor which determines the value. The guidelines contain a description of prohibited materials under which agricultural chemicals and hazardous materials, but does not refer to specific chemicals legislation (see paragraph 2.11.2). In answering questions on waste codes the European Commission (EC, 2012) refers to the guidelines of ISRI and Bureau International de Recyclage (BIR), but indicates that these codes do not have any legally binding impact[9].

2.8 Waste or a product?

At present, there are no formal European EoW criteria for plastics.[10] Interviewees indicate that this leaves waste handling companies, compounders and moulders some space to define whether they deal with waste or with a product. Waste should be compliant with the waste regulations, products with the relevant product regulations, such as REACH and RoHS (See Figure 5).

[9] Allowable Contamination
Unspecified materials must not exceed 2% of total bale weight. Bales which contain over 2% will be subjected to reduction in the contracted price of the material as well as charges for disposal of the contaminants. The reduced percentage will vary depending upon the amount and type of contamination. Quality of the baled plastic is the primary factor which determines the value.

Prohibited Material
Certain materials are understood to be specified as "prohibited." Such materials will render the bale "non-specification" and may cause some customers to reject the entire shipment. These may include plastic materials which have a deleterious effect on each other when reprocessed, and materials such as agricultural chemicals, hazardous materials, flammable liquids and/or their containers, and medical waste.

[10] Waste Framework Directive Article 6.4. Where criteria have not been set at Community level under the procedure set out in paragraphs 1 and 2, Member States may decide case by case whether certain waste has ceased to be waste taking into account the applicable case law. They shall notify the Commission of such decisions in accordance with Directive 98/34/EC of the European Parliament and of the Council of 22 June 1998 laying down a procedure for the provision of information in the field of technical standards and regulations and of rules on Information Society services (1) where so required by that Directive.

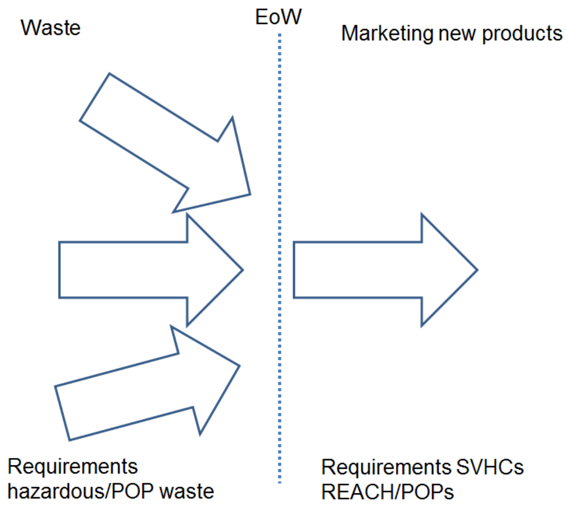

Figure 5. Requirements in the two legislative frames of the waste-product chain. If the material is still waste, the Waste Framework applies, if the material is sold as substance, mixture or article REACH and/or specific product regulations apply. There is often discussion whether a material is still waste or not.

Most interviewees up to the compounder stage indicated that they only treat waste, indicating that scrap is often denoted as waste as well. In the last step, when scrap or pellets are delivered from a compounder or a moulder to a producing company, the material is delivered as product. Van Werven receives and sells waste material. ARN Recycling BV gets material from the shredder companies as waste and sells scrap as waste material as well. They have questions on registration of this material as product under REACH. ARN Recycling BV mentions the RWS tool 'Afval of grondstof' (Rijkswaterstaat, 2016), but this does not provide a clear answer to the question whether they deal with waste or a product.

PHB-Coolrec indicated that the material becomes a product after compounding, but indicated that in Germany scrap is already considered as a product, hinting also at national differences. AKG/Veolia Polymers receives scrap or flakes from other companies, and turns this into pellets to be delivered to an end user. The pellets are considered as a product. The uncertainties around EoW, and thus whether the material is waste or a product, may lead to discussions with the Inspectorates on which legislation applies.

Companies making articles or products may communicate that they use recycled material for reasons of sustainability, but they prefer to carry the label producer rather than the label waste company. An important reason to do so is image, other important reasons are requirements for the plant location and the permits that are needed for waste handling. Most waste treatment companies have their locations on easy accessible industrial sites outside the main cities. Being waste or new product does impact possible actions under REACH like i.e. registration and, when SVHCs are present above their specific limit concentrations, specific information obligations and the possible need to apply for authorization.

2.9 Transport

Transport is of importance as the obligations differ depending whether waste or a product is being transported. Figure 2 shows the chains from pure waste, e.g. municipal waste or end of life vehicles (ELVs) to recycled polymers with a high grade of purity being applied in new products. Somewhere along this route waste turns into a product. As indicated in the paragraphs above, this transition happens relatively far into the waste chain. The consequence is that transport in the first part of the chain considers the transport of waste.

There are two options in managing waste: Recovery (nuttige toepassing) and disposal (verwijdering). Recovery and disposal are defined in article 3 of Waste Framework Directive 2008/98/EC. Different regimes apply to waste that is meant for disposal[11] and waste recovery. Waste that is meant for recovery can be transported following two different procedures:

a. Green list procedure
   The so-called green list procedure is the most simple one of the two as a prior consent of the authorities is not needed. The waste needs:
   - To be incorporated on the green list
   - Have an OECD country as destination
   - Should be recovered

   Dangerous substances are not incorporated on the green list[12]. However, the transport needs to be accompanied by a so-called Annex VII form, which should demonstrate that the waste is to be properly treated and there needs to be a contract between the delivery and the receiving company.

b. Notification procedure
   Prior to the transport a written consent is needed from all authorities of the countries of export, transit and import. This procedure is needed for wastes that are on the so-called orange list of the Waste Shipment Regulation (WSR), or which are not incorporated in one of the waste lists. The request should be submitted in the country of export and is valid for a series of similar transports. The exporting country informs the authorities in the other participating countries.

Some of the companies interviewed used the notification procedure, others the green list procedure. Van Werven transports their material (scrap or flakes) as green list material accompanied by an annex VII form.

[11] Different regimes apply to shipments of wastes for disposal and for recovery, as well as to hazardous and "green-listed" non-hazardous wastes. The shipment of hazardous wastes and of wastes destined for disposal is generally subject to notification procedures with the prior written consent of all relevant authorities of dispatch, transit and destination. However, as a rule, the shipment of “green-listed” wastes for recovery within the EU and OECD does not require the consent of the authorities. http://ec.europa.eu/environment/waste/shipments/

[12] From DK-EPA 2011: It must be emphasised that green listed wastes that are listed in Annex III, IIIA or IIIB are waste fractions that are considered relatively unproblematic in terms of processing and the environment, and can therefore be easily incorporated as raw materials in the manufacture of new products. A precondition for this is that the wastes do not contain other waste fractions, and for this reason there are relatively strict requirements regarding the purity of this waste.

Data on the notification procedure were available on the Inspectorates (ILENTs) website[13]. In all cases waste was identified by the EURAL waste codes (European Waste Code; decision 2014/955/EC). The codes as provided in the waste shipment regulation (EC/1013/2006) under V (Waste subject to the export prohibition in article 36) Part 1 List A (Annex IX to the Basel Convention), such as B3010, were not used for the identification.
The received waste streams notified were labelled with the codes in annex V Part 2 (Wastes listed in the Annex to Decision 2000/532/EC) in regulation EC/1013/2006 as mixed municipal waste (20 03 01), mixed packaging (15 01 06), plastic and rubber (19 12 04), other wastes (including mixtures of materials) from mechanical treatment of wastes other than those mentioned in 19 12 11 (19 12 12) or fluff-light fraction and dust other than those mentioned in 19 10 03 (19 10 04) dependent on the company and the place in the waste chain.
Treatment identification followed directive 2008/98/EC. Treatment was often characterized as R12 followed by R3, R4 and R1 or R12 followed by R1. Composition of the material was sometimes quite well defined (ABS 0.91%; PS 34.75%; Metals 3.13%; PE and PP 8.63%; Plastic with flame retardants 45.34%; remaining 7.24%) and sometimes more generic. In the latter case only EURAL CODE (15 01 02) and ‘plastic packaging’ may be provided without further specification.

[13] https://www.ilent.nl/english2/international_shipment_of_waste/notification_procedure/
https://www.ilent.nl/onderwerpen/transport/afval_over_de_grens_evoa/beschikkingen_online/beschikkingenonline.aspx

3 Challenges

Most issues concerning SVHCs in polymers concern additives. Additives are added to polymers because they improve the charcteristics and the functionality of the polymer. Examples are inorganic pigments applied to a wide range of thermoplastics, heat stabilizers that prevent PVC from degrading during processing, and antioxidants and UV-stabilizers that are applied in polypropylene. There are several thousands of additives applied to polymers which can be divided into a dozen classes according their functionality (Fishbein, 1984; Bart, 2005; Lithner et al 2011). Seventy to eighty percent of the world production of additives is used for PVC, followed by 10% for PE and PP (Bart 2005, Lithner et al 2011). Additives that are often related to various health and safety hazard issues are flame retardants (chlorinated and brominated, for instance commercial tetraBDE and commercial pentaBDE), plasticizers (phthalates) and heavy metals stabilizers (cadmium and lead) (Murphy, 1999; Bart, 2005). From the substances in annex XIV and annex XVII of REACH and in the Stockholm Convention mainly plasticizers, flame retardants and metals are substances that may cause problems with recycling. A search in the waste database of Rijkswaterstaat (RWS) indicates that data on these substances are hard to retrieve, in contrast to substances like mercury and PCBs which have specific entries in the waste registration.

From the interviews it was deduced that at present, difficulties with recycling material containing SVHCs is most likely to appear for waste originating from construction, automotive and electronics. These so-called long service life materials (or articles) were identified to potentially contain higher concentrations SVHCs such as flame retardants, PCBs, lead, cadmium and (other) heavy metals. This depends on the type of polymer and the application (e.g. flame retardants in electronics, lead as stabilizer in PVC window frames). It also depends on the time of application when these additives were not yet identified as SVHCs and consequently were still allowed for use. They have now been prohibited and are replaced by less hazardous alternatives. Examples are the replacement of lead stabilisers in PVC by calcium-based stabilisers, or the replacement of the flame retardant HBCDD by a polymer based flame retardant.

Plastics collected in a uniform waste stream and with a short service life, such as food packaging materials, plastics for pharmaceutical packaging etc. are expected to contain no, or only little SVHCs. Consequently, these materials are expected to be recyclable without any substantial SVHC related issues. Sometimes legal obligations may lead to deviating circumstances, as the application of flame retardants in Korean packaging polystyrene and the application of fire retardants in fabric for the UK and Irish market indicates. It is recommended to share such information and to keep the waste stream separate if applicable.
PVC is a polymer with a relative high amount of additives compared to other polymers (Bart, 2005; Lithner et al 2011). With regard to material types, soft PVC was identified as a material for which presently most discussion is about recycling and the use of DEHP as plasticiser. For rigid

PVC, cadmium and lead, which were used as stabilizers, may lead to problems in recycling. However, as will be discussed later, in terms of possible recycling perspectives, it is important to distinguish between these two forms of PVC, as the possible exposure profile of SVHCs from use in PVC may differ significantly between rigid and soft PVC. For ABS, PC, PE, PP and PS it is less clear from the interviews whether these polymer waste streams contain a relevant amount of SVHCs.

3.1 Identification of main challenges

SVHCs in plastic waste streams are identified as a potential problem for recycling because of uncertainties, because of challenges in the waste chain itself and because it is expected that SVHCs present will limit the marketing and use of all recoverable materials, including investments in innovation and new developments.

3.1.1 Uncertainties:

The following uncertainties are flagged by the interviewees to limit investments, innovation and new developments:

- Uncertainty in the chain with regard to SVHCs (are they in of not?).
- Uncertainty in legislation and enforcement with respect to SVHCs in the waste stream.
- Uncertainty surrounding the possible long list of future SVHCs (CORAP list/SIN list/ZZS list).
- Uncertainty surrounding the sampling and analysis methods and obligations (including connected costs) of future SVHCs
- Uncertainty if the possible presence of SVHCs or potential future SVHCs will limit the recovery of waste.
- Uncertainty whether the waste material can be transported under entry B3010 of the 'Green List' or whether it should be notified as hazardous waste.
- Uncertainty with regard to the role of the different actors in the value chain in relation to the EoW criteria: which company should apply for Authorization in case of SVHC containing secondary material above the limit value?
- Need to apply waste limits to all individual items in one entity or to the entity as a whole (e.g. to the whole car versus SVHC-containing spare parts) is uncertain. A recent High Court decision on REACH indicated that individual parts of articles should be considered separately within the REACH framework: an article in a complex product is an article in itself[14].

Legislation, presence of SVHCs and End-of-Waste

Many of the uncertainties flagged have to do with legislation. Some of these uncertainties are related to the aspects of time and some with interpretation of the Waste Framework Directive and the REACH Regulation. Several interviewees indicated that continuity in policy, regulations and implementation of the regulation is of importance. Investments in personnel, equipment and in innovation require a considerable period of time to implement and become profitable.

[14] http://curia.europa.eu/jcms/upload/docs/application/pdf/2015-09/cp150100en.pdf , Case C-106/14, European Court of Justice, 10 Sept. 2015

Consequently, future perspectives need to be clear for company stakeholders. According to the stakeholders interviewed (paragraph 1.2), legislation should support the long term perspective for recycling.

From the side of the chemicals regulations, harmonized classification of substances under the Classification and Labelling of Products Regulation and Candidate Listing of substances under the REACH Regulation is not always straightforward to predict (for example, because the knowledge base on a substance is evolving with time). Hence, this creates uncertainty with regard to the long-term recyclability in view of the legal obligations of materials delivered to the stakeholders. This should also be viewed in the light of investments and the long-term contracts discussed below.

Uncertainties surrounding the EoW relate to transport obligations and authorisation. From the interviews it was concluded that in most cases material is transported as waste and not as a product. The latter requires less paperwork, but the product has to meet the requirements of the REACH regulation. Besides the differences in interpretation in using either the Green list procedure (including annex VII registration form pursuant the Shipment of Waste Regulation (EC No 1013/2006) or the notification procedure, the survey also suggested that the classification as hazardous may differ among the European member states. This was also suggested by some written sources (See for instance COM 2015b).

On plastic waste the European Commission answered in their Frequently asked questions on Regulation (EC) 1013/2006 on Shipments of waste (COM, 2012) that Plastic waste shall be classified as B3010:

- if they are not mixed with other wastes (this includes mixtures with hazardous as well as non-hazardous metals and inorganic materials mentioned in B3)
- the plastic waste is prepared to a specification
- the polymers and copolymers are not halogenated (except certain fluorinated polymers)

The Frequently asked questions (COM, 2012) state further that post-consumer plastic waste cannot be assigned as B3010, but that post-consumer plastic waste shall be classified as “plastics” according Annex V, Part 2 Waste Shipment Regulation, List of Waste (LOW) code 20 01 39 and that there is no Basel code assigning post-consumer plastic waste. In the data retrieved from the ILENT database (see previous chapter), some waste shipments used the LoW code 20 01 39 and B3010 together with the waste type ‘plastic scrap’ or ‘plastic waste’, others used the LoW code 19 12 12 or 15 01 06 and plastic or plastic packaging material. The data showed that similar type of material can have different LoW codes.

As soon as the EoW is passed and a material falls under REACH, questions may rise what has to be done (registration, authorisation), and which actor in the chain has to follow-up on the material under REACH. The costs of these procedures may give rise to further questions: who has to pay and will these administrative costs frustrate economical recycling?

3.1.2 *Waste related matters:*

The following waste related matters are flagged by the interviewees to limit investments, innovation and new developments:

- Awareness and measurements. From its outside appearance, the possible SVHC content of the material cannot be identified. Measurements may therefore be necessary.
- Identification of substances in waste through measurements needs to be effective, efficient and instantaneous because otherwise the whole recycling process is delayed.
- In legislation, limit values are indicated for hazardous substances of which SVHCs. However, limit values are meaningless without a related sampling and identified test method.
- (Lack of) Separation possibilities of various items from the waste stream.
- Cost-effectiveness. Questions around feasibility and cost-effectiveness of sorting out SVHC-containing items. If it is carried out there should be incentives to do so (currently, SVHC-measurements take place further in the chain).

Awareness, measurements and separability

Proper separation of SVHC-containing items in the waste stream can be brought back to four different topics:

a. Awareness with regard to the composition of waste
b. Measurements, including effective and efficient screening technology
c. Separation possibility of individual items containing SVHCs from the waste stream and individual SVHCs from the waste material
d. Costs-effectiveness of measures

Considering awareness, the interviews showed that the sector primarily focuses on other polymers and other materials (rubber, wood, cork) being present in the waste stream as impurity. First focus is not on SVHCs. In the ILT EVOA permits database, the removal of impurities such as specific polymers, wood, metals, glass and PUR is being mentioned [NL210051 Plastic Herverwerking Brabant Galloo France S.A.]. From the interviews it is concluded that separating the different polymers within the limits as laid down in for instance ISRI (2016), and removing materials such as rubber and wood down to <2% contamination seems common practice (see also section 2.7). The incentive for this purification step relates to the product quality that is most often required further down in the chain, namely one type of polymer. From the interviews is furthermore concluded that the different actors in the value chain of waste are much less aware of possible contamination of the stream with hazardous substances (e.g. SVHCs) that are not specifically communicated to the sector for their need to be removed (like is the case with rubber, wood and cork). Some examples in which items with a high content of hazardous substances are selectively removed are the removal of liquids and tyres during car dismantling and the removal of refrigerator coolants and compressor fluids. Dismantling companies are not aware of the presence of flame retardants or plasticisers that may be present in the ELVs, whereas some electronic waste dismantlers are aware of the potential presence of brominated flame retardants as indicated in some export notifications (ILT, 2017). The larger companies more at the end of the waste chains and delivering to a producer of articles that will use the recycled polymers are aware of the possibility that hazardous substances may be present.

Analysis of hazardous substances of which SVHCs possibly present in the waste stream is carried out preferably further down in the waste chain. At the beginning of the waste treatment process, the material is highly inhomogeneous and measuring all individual items on the presence of specific SVHCs is technically and economically not feasible, e.g. ELVs or WEEE. The interviewees indicate that material containing SVHCs cannot easily be recognized based on appearance and measurements would impede the primary process of waste handling. The interviewees suggest that measurements are more feasible in the later stages of the waste chain when the material has been sorted to polymer type and has been grinded to yield a more homogeneous mixture. The interviews indicated that more at the beginning of the waste chain, monitoring of the waste stream composition is conducted, probably by GCMS (Gas chromatography combined with mass spectrometry). They sketch that this monitoring takes place at low frequency on shredder material batches with the aim to identify SVHCs in the waste stream, but not to remove individual items. In these types of measurements, results are generated in parallel to the waste treatment process and are used to flag potential hurdles of upcoming SVHCs in a more generic way. Further down in the waste chain, identification of SVHCs has also the function to meet the customer request for a SVHC-free polymer. However, at both phases of the process, SVHC removal is an elaborative task and often not possible with the current techniques.

Measuring may deliver a part, but not the whole solution to dealing with SVHCs that may be present in the waste. A rapid screening technique is to analyse the waste material by X-ray fluorescence (XRF). Using XRF enables to identify e.g. whether bromine (Br) is present, but does not enable to identify the SVHC content up to substance level. Other techniques, like GCMS, that have the possibility to identify which substances are present are often not applicable in the current practice of the waste treatment process as it takes considerable time between sampling and results.

Preferably, separation of SVHC-containing items should take place at the beginning of the chain, where the origin of the material is still clear. In practice this is almost never done, because of various reasons. As we have seen, waste does not come in a single chain, but often through an international network, where in the first stages mixed waste is separated into different polymer streams which are further treated. Certain items, for instance the ones containing hazardous substances, are removed if this is laid down as a requirement in legislation, or when removal is being paid for. Examples are the battery, liquids and the tyres from ELVs. Similarly, the removal of PCBs in capacitors and transformers is regulated. It is favourable to organise such a removal in the first stages of the waste chain. In the examples above, legislation is clear and generic and there is clarity on the items to remove. The situation becomes much more complicated when only certain items of a kind contain the SVHC, such as the chairs of one certain type of car but not one other, or when these items are rather small.

Removal of contamination such as other polymers, rubber or wood is done instantly, manually and visually. Removal of SVHC containing items is much more difficult. In a recent Nordic Council of Ministers (2017) report it is also stated that "*Evidence suggests that WEEE treatment processes with significant low-tech elements, including manual disassembly and separation of WEEE, can currently achieve significantly better plastics recycling than highly mechanised and automated alternatives.*" (Baxter et al., 2015). This contrasts several advocacies of technical solutions stating for instance that advanced separation techniques are already in use in the waste management sector and globally available.

From the interviews is concluded that incentives are essential to further organize early separation of SVHC containing waste. Various interviewees further in the chain indicated that a lower percentage of hazardous substance contamination could in principle be achieved, but that there was a trade-off between a higher purity and increasing costs to reach that purity. They also indicated that it is more easy to separate waste in homogeneous waste streams in an early phase of the waste treatment process than in a later phase in the waste treatment process. Interestingly, they indicate that high level separation in an earlier phase in the process may be achieved at lower costs when the overall waste treatment process is considered, but at higher costs for the individual companies at the particular phase of the process. STIBA and ARN Recycling BV indicated that until some years ago there was a regulatory incentive to remove glass from end-of-live vehicles before shredding. However, the business model in place makes early removal of glass economically unfeasible now this incentive has been removed. Before, the glass was being dismantled and recycled into new glass. Nowadays, the glass is delivered to ARN recycling BV and separated into the 1-4 and 4-8 mineral fraction and sold for recovery[15].

Main question is whether the waste can easily be separated and that depend both on measurements and feasibility to separate the various streams.

In summary, from the interviews is concluded that targeted handling of SVHC containing waste requires early detection and separation in the waste treatment process. Early detection and separation of SVHC containing waste is hampered by the difficulty to recognize this material *on sight* and the absence of appropriate techniques to analyse waste samples on the presence of SVHCs sufficiently quick while dealing with a strongly inhomogeneous mixture. Current experience suggests that (legislative) incentives can be essential to allow for otherwise economically unfavourable waste treatment activities such as the (manual) removal of certain materials from the waste stream.

3.1.3 *Feasible products: REACH Regulation*

The following REACH Regulation related matters are flagged by the interviewees to limit investments, innovation and new developments:

[15] Nog navragen bij STIBA/ARN waarom dit niet meer gebeurt

- Producers can be reluctant to process SVHC containing material in their articles.
- There is a possibility that the recovered material can no longer be brought onto the EU market without granted authorization and until it is granted, it is unclear whether or not it will and to what conditions.
- When an application for authorisation is not granted and if the SVHC content in the material cannot be reduced to below the SVHC threshold, the recyclate cannot be marketed.
- Application for authorization is indicated as cumbersome due to the:
  - High number of different uses of the recyclate;
  - Relatively low volume per use;
  - High (yearly) variability in the composition of the material, including the content and identity of the SVHC.
- Small margin with virgin material in terms of unit-costs is further challenged due to:
  - The costs involved in the application for authorisation; or alternatively
  - Cleaning/purifying the material to reduce the SVHC content to below the authorization limit.

To comply with the REACH Regulation, the material should be well-defined and the composition should be known within reasonable limits. In order to accomplish characterisation of the material, it should be relatively homogeneous, which is not necessarily the case with waste in the first stages of the waste chain.

It is important to realize that REACH only starts to apply as soon as a substance or a mixture is no longer considered waste. In other words: if it passed the EoW criteria. When waste is directly converted into a new article (in other words, if the EoW is only reached when a producer converts the waste into an article), registration and authorization requirements under REACH do not apply for the recyclate. The Waste Framework Directive in that case continues to apply on the waste and waste treatment processes (see Annex I).

Marketing articles from recyclate as waste however, has two interesting consequences. Firstly, the producer has to denote himself as a company that produces articles from waste and has to comply with the waste regulations (e.g. the producer becomes a waste treatment company). Secondly, social acceptance of products made from waste is indicated by some interviewees to be lower than products made from 'recycled material' because 'waste' is generally associated with material that one should get rid of. In the present social climate, it is therefore anticipated that consumers may be more willing to buy *products made from recycled material* than *products made from waste*. The impact of a label 'waste material', and the reluctance to accept such a product may be larger in consumer products than to for instance building products.

3.2 Possible ways to address the challenges

The following provides options for improvement related to the challenges formulated in the previous chapter.

3.2.1 *Challenges related to uncertainties*

Clear communication and clear guidelines are a key for addressing several of the uncertainties voiced by the interviewees, especially where the uncertainties relate to the interpretation of the Waste Framework Directive or other regulatory frameworks that act on the collection, recycling and bringing on the market of waste. In the context of the Waste Framework Directive, further harmonization of the interpretation of the End of Waste at EU level may be needed. However, it should be noted also that legislation is inherently a dynamic process and therefore will be dynamic in the future. The only way to anticipate to these dynamics is to arrange the proper information and to be prepared. Part of this may be the task of the European and national authorities, e.g. through help desks and to provide clear information on the developments, part is task of the branch organisations.

With regard to uncertainties related to (future) market perspectives and intelligent ways to invest and innovate sharing knowledge on the material composition is essential. This not only involves materials that are freed as waste today, but also knowledge on what will be expected in say 10 to 50 years. NRK indicated that their European sister organisation Polymer Comply Europe[16] runs a database in which information on SVHCs and plastics has been incorporated, which is an example of an initiative at branch level that may provide insight in (future) waste compositions (see also section 2.12.2). Furthermore, from the interviews it is suggested essential to develop a clear policy with regard to establishing a circular economy while working towards a non-toxic environment.

Uncertainties with regard to the nature and magnitude of the waste streams may be addressed by working on the volumes processed per company and the type of material collected. Most companies approached recycled volumes of 40.000 – 60.000 ton waste per annum (see section/paragraph 2.5). Most waste originate from collection by municipalities, either from municipal collection points (WEEE, garden furniture, polystyrene and other packaging material, PVC building material) or from the regular municipal waste collection (see chapter 2.4). All companies interviewed recycled only a limited number of thermoplasts (ABS, PC, PE, PP, PS, PVC) and indicated that they were limited to recycling only these, because these are among the most abundant polymers on the market (see chapter 2.4). According to Plastics Europe (2013) about 66% of European plastics consists of PE, PP, PS and PVC. Overall, about 70% of the synthetic polymers are thermoplasts, whereas the remaining 30% is made up by thermosets and elastomers (Groover 2014). Proper selection of waste materials may be one way to reduce the uncertainties in terms of available volumes for some specific companies, but does not solve the identified problems for the whole sector. Uncertainties around separability of waste has been addressed in section 3.1.2.

Uncertainties related to the continuity of the market demand is in most cases safeguarded within the waste chain by long term contracts

[16] http://www.polymercomplyeurope.eu/pce-services/sds-r-tool-service

between the various actors. The long term contracts have a number of advantages and disadvantages. Long term contracts generate a fixed price over a longer time, may guarantee certain quality, but have limited flexibility when the market is changing. To cite one interviewee "Waste cannot be stopped, it keeps coming". This is an important difference to virgin material, where supply can be stopped when there is limited demand. Some interviewees indeed indicated that the global market for waste is changing. In particular they hint that transports of waste to China is currently decreasing due to smaller market demands in the east, a more stringent waste treatment policy in China and more inspections on the European side[17]. Also the Dutch Inspectorate indicates that exports of plastic waste to India and China, mainly PET and foils, have ceased since 2010 (ILT, 2011). Furthermore, awareness is growing that it is better to recycle in Europe than to allow for uncontrolled transport of the material to outside the EU followed by an import of cheap products based on these recyclates. This upcoming trend is partly due to bad experiences with the export of WEEE and recycling practices aiming at recovery of precious metals. Another factor that plays a role is that it becomes increasingly difficult for European recyclers to get good quality waste because the number of players on the plastic recycling market has increased compared to a decade ago.

3.2.2 Challenges related to the waste stream

Data and awareness raising

From a theoretical point of view, a first step to a solution is to identify the waste streams containing specific SVHCs and to organise collection and handling of waste by sector. Information on the size of the various waste streams and the polymers they are composed of may be very helpful in informing public and stakeholders (see Table 2). Packaging is by far the largest polymer waste stream and rather short-cyclic. The data provided in Plastics Europe (2015) show that different polymers are applied in different use categories (i.e. automobiles, electronics, building). A large amount of PE and PP is applied in packaging, whereas a large amount of PS and PVC is applied in building and construction. Packaging consists for a considerable amount of PET, PE and PP, which contain a relative small amount of additives. A database containing information on the combination polymer/application/additive applied, such as initiated by Polymer Comply Europe, is very helpful to raise awareness among the recycling companies on possible hazardous substances present. For analysing the impediments of SVHCs in the recycling of plastics, it is further key to know whether the different waste streams are kept separate and how these are treated.

[17] The Danish practical guidelines on classifying Green List waste (Danish EPA, 2011) writes: "Note that China, one of the main recipients of plastic wastes from Denmark, has introduced a prohibition against import of plastic household and agricultural wastes because of the high level of contaminants. This means that irrespective of contamination, the export to China of agricultural plastics, for instance, is forbidden."

Table 2. Plastic waste per application in 1000 metric tonnes. Data from Denmark, Norway, Sweden and Finland derived from Andersen et al., (2015), data from the Netherlands derived from Jetten (2015). The last column provides the amount recycled within the Netherlands.

<table>
<tr><th>Application</th><th>DK</th><th>N</th><th>S</th><th>SF</th><th>NL</th><th>NL recycling</th></tr>
<tr><td>Packaging</td><td>207</td><td>149</td><td>217</td><td>116</td><td>470</td><td>238</td></tr>
<tr><td>Building-/Construction</td><td>17</td><td>12</td><td>15</td><td>12</td><td>82</td><td rowspan="6">77</td></tr>
<tr><td>Automotive</td><td>11</td><td>11</td><td>18</td><td>10</td><td>40</td></tr>
<tr><td>WEEE</td><td>17</td><td>18</td><td>31</td><td>15</td><td>62</td></tr>
<tr><td>Houseware</td><td>190</td><td>120</td><td>15</td><td>11</td><td>49</td></tr>
<tr><td>Agriculture</td><td>16</td><td>12</td><td>17</td><td>10</td><td>38</td></tr>
<tr><td>Other (Furniture etc.)</td><td>16</td><td>12</td><td>17</td><td>10</td><td>108</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Total</td><td>474</td><td>334</td><td>330</td><td>184</td><td>849</td><td></td></tr>
<tr><td>Kg/capita</td><td>56</td><td>48</td><td>39</td><td>39</td><td>50</td><td></td></tr>
</table>

Organising proper waste collection

The first step addressing the core of the waste-treatment process, is to organize waste collection in a way that keeps the plastics containing SVHCs separate from those that don’t. The main aim of this is to keep the ‘non-polluted’ waste streams free of SVHCs. Preferably, separation of SVHC-containing from SVHC-free waste is achieved as early in the waste-treatment process as possible to facilitate environmentally sound management of the SVHC containing material. To achieve that, problems described above related to costs of measuring and separation and economic feasibility need to be addressed first. From the interviews it became clear that the collection of PVC pipes and PVC window frames are excellent examples where application specific collection and recycling already exist. Interestingly, this collection and recycling practice is not driven by the presence of SVHCs, but by other incentives. For a number of the other polymers/application combinations this is more difficult as they are currently collected altogether, i.e. in municipality collection sites. Further separation may be useful there if relevant and feasible. Separate collection of building EPS and packaging EPS on such municipal collection points is highly recommended, but should be accompanied by public awareness. In this case, the SVHC containing EPS building waste stream can be easily separated from the non-SVHC containing one of packaging EPS. However, even for this latter waste stream that is considered to be SVHC-free the question remains what level of proof is needed to confirm. In cases where the SVHC-containing items are easy to recognize, separation may also take place in the next stage where the waste is being separated according to polymer.

Incentives

It may also be interesting to improve separation for automotive waste where current practice is that nearly intact objects are shredded and room for further optimization of the process may be identified in terms of yielding ‘more SVHC-clean’ waste streams (see 2.11.2). It needs a certain creativity to find incentives to have items removed if possible in terms of identification (where?) and if feasible in terms of practicality (can they easily be removed?). It seems not very feasible to remove

POP-BDE-containing car seats from a car of a certain type and age, if most other cars do not contain POP-BDE in their seats. In such cases, a discussion on what is acceptable from a substance point of view and what is feasible seems necessary to achieve a realistic way forward.
For a European perspective on the waste streams it is also necessary to have insight in the legislation (including enforcement), incentives and taxes in other European countries. Literature sources suggest that these may differ and thus drive certain waste streams and certain practices.

3.2.3 Challenges related to REACH, registration and authorization

Legislation that regulates the amount of substances in products takes the hazard classification in the CLP regulation for the classification and labelling of products (CLP) as a starting point. Thus, the amount of a substance in products is regulated in a general way, by a generic limit value, and is thus quite rigid. The advantage doing this, is that the system is relatively clear and easy to convey (see Table 3 for a comparison). Since 1 June 2015 the CLP regulation is also applicable to waste after retrieval of directive 67/548.
The so-called tailor made solutions do not focus on a specific substance only, but rather on a combination of substance and application. In contrast to the generic approach, which generally takes hazard as a starting point, it takes exposure of the substance from that specific application into account. Examples are the recycling exemption of cadmium in PVC in which ‘closed loop’ is applied together with labelling the recycled material (REACH entry 23.4), PFOS use as mist suppressants for non-decorative hard chromium (VI) plating in closed loop systems accompanied by controlled emissions and proper waste treatment (POP Regulation annex I), recycling of Expanded Polystyrene (EPS) containing HBCDD through solvolyse through which the HBCDD is removed and destroyed (Basel Convention), Industrial use of recycled soft PVC containing DEHP in polymer processing excluding the application in a number of applications such as children toys, childcare applications and erasers (REACH authorisation DEHP). Such tailor made solutions may be allowed for a limited time or be accompanied by a reviewing clause.

Table 3. Differences between a standard approach taking hazard as a starting point and a tailor made approach taking risk of a certain application as starting point. Some characteristics for tailor made solutions are also provided.

Standard approach	**Tailor made approach**
Hazard	Risk
Substance	Substance/application
Independent of application	Dependent on application
Generic exposure	Exposure per application
Less complex	More complex
Limited data needed	Lot of data needed
Simple to convey	Difficult to convey
Focus on safety	Focus on applicability
	Tailor made solutions
	Exposure of the specific applications as starting point
	Individual exposure and distribution in the environment as line of reasoning
	Removal of SVHC from the matrix above recycling if feasible
	Closed loop preferable
	Following SVHC during life cycle/ Labelling
	Closed applications rather than open ones
	Limited number of applications allowed
	Limited number of large items rather than many small items
	Regular evaluation/reviewing clause

High quality separation of waste streams at the source will ideally yield more-homogeneous polymer streams that are more constant in their composition (e.g. have a lower degree of variability of their chemical composition throughout the year). Consequently, higher quality separation may be expected to facilitate easier registration and authorization processes where needed. It is expected that to achieve more clean waste streams, good insight in the occurrence of SVHCs in plastics is required. Good insight in composition of the material (polymer, SVHCs, (other) additives) will also reduce costs for registration under REACH. One way to come to clean waste streams is to keep the recovered material close to its virgin composition. Although chances are small that recyclers will be able to make use of the exemption provided by article 2(7)(d) of REACH, this may translate in reduced costs for filing an application for authorization when a similar application for authorization is made (and granted) for the virgin material.

A possible downside of producing more homogeneous waste streams is that it may also lead to a reduction of volume per stream of recyclate and as a consequence increase the unit-costs for the waste treatment process.

The ambition to produce homogeneous waste streams may also in more general terms facilitate safe re-use of materials. Following a pragmatic approach, first separation could proceed along the expected potential to encounter SVHCs in streams that are more, or less, interesting for recycling purposes, i.e. identify waste streams with:

- No present SVHC concern with potential for recycling;
- SVHC concern and high potential and high added value for recycling;
- SVHC concern and some potential for recycling that needs further investment;
- SVHC concern and low potential and low added value for recycling, containing such high amounts of SVHCs that incineration is the only sensible option.

For those materials that contain SVHCs and have a potential for recycling:

- Identify possible uses of 'zero' emission;
- Identify possible uses where socio-economic considerations (including facilitating a circular economy) outweigh the human and environmental health risks upon use;
- When authorization is granted for a specific material and use, organize waste collection such that for the recovered material one could join the authorization of the 'virgin' material. Where possible, create an incentive for use of recycled material containing SVHCs in a responsible and safe manner;
- Where possible increase the scale for recycling to larger volumes.

From the interviews is extracted that first steps in the direction of recycling SVHC containing plastics concern closed loop applications in which the material is labelled and exposure is expected to be controlled. The currently single example is in three-layered PVC pipes, where the cadmium containing recyclate is sandwiched between two cadmium-free layers.

More general applications of recyclate where SVHCs are not an issue are found in articles where human exposure is relatively limited, e.g. buckets, adjustable feet of office tables, electronics such as vacuum cleaners, irons and the outer layer of coffee machines. In food contact materials (FCMs) on the other hand, where exposure is much more likely, virgin material is still typically applied out of quality considerations. In the Netherlands, exception is the closed loop system established for PET bottles. Further evaluation of possible other developments in this direction at EU level may be worthwhile to consider. There are some cases where SVHCs have been found in FCMs. An overview on the occurrence of SVHCs in FCMs (incidents or regular) and in other materials, the amounts observed and their relevance in terms of specific recycling needs would add to the possibilities of high value recycling of these plastics. Preferably, this should be set up in an international cooperation to be maximally useful.

3.2.4 *Challenges related to the whole chain*

Some of the challenges cannot be related to either the waste stage or the product stage, but have to do with the whole chain. The point where the EoW is applied is such a challenge. This point determines whether the material is considered waste or a product, and thus which legislation applies. However, the EoW also influences the appreciation of the material by the general public. The interviews indicated that some companies plea for applying EoW early in the chain, where the origin of the material is still clear. On the contrary, the material is more heterogeneous and thus it is more difficult to carry out relevant measurements considering the composition. It may be more feasible in relatively homogeneous waste streams, but as the origin is more clear, the necessity to measure it exact composition is less according to some stakeholders. Interviewees also indicated that they may have to register the recyclate and the chance for authorisation increases when the EoW is applied earlier in the chain. Measurements are accompanied by costs which should be charged to the clients.
The place where waste turns into a product is rather arbitrary, but may have a large impact on permits, location requirements and transport requirements. Currently, in the absence of EoW criteria for plastics, there are no Europe-wide and clear criteria where to apply EoW, which provide stakeholders some flexibility but also increases uncertainty.

From the interviews it was concluded that it may require case-by-case assessment to identify the most preferred regulatory composition, answering the question "where in the value chain of my recycled plastic should the EoW be positioned to make optimum use of existing regulatory frameworks (Waste Framework Directive, Transport, Municipality regulation, REACH). In the previous sections it has been shown that there are limitations to the possible places in the waste chain where EoW can be positioned; in the beginning the heterogeneity will limit the application of REACH, at the end the image of Waste Treatment Company and the obligations related to the waste legislation may limit the application of the waste legislation. Table 4 compiles some important differences between waste and a product.

Table 4. Some important differences between waste treatment and production (substance, mixture or article). The first takes place in the beginning of the waste chain, the latter at the end.

	Waste	**Product**
Recycle	As waste	As secondary material (substance, mixture, article)
Material origin	Knowledge available	Origin of recyclate variable and unknown
Regulatory framework	Waste legislation	REACH
Material characteristics	(Highly) heterogeneous in composition (2.7)	Homogeneous well-defined material (2.11.3)
	Highly variable in time (batches) (2.12.3; 2.12.4)	Composition constant in time (2.1.3; 2.12.3)
	Measurements less needed and more difficult because of heterogeneity (2.12.4)	Measurements needed before marketing
Regulatory demands	Information on the presence of hazardous substances required	Relatively strict description of the material composition required (substance identity)
	Exact composition not required (2.7)	Information requirement on health and safety and exposure characteristics
	Local (municipal) permits on waste treatment required and possibly more restrictive than production facilities (2.8)	
		Registration obligation per substance per manufacturer or importer
		Authorisation obligation per substance per company when SVHCs are above the threshold for authorisation
	Transport of waste is more demanding than transport of substances (2.9)	Transport of substances, mixtures or articles less demanding than waste
Societal perception (2.8)	Waste is dirty	Materials (substances, mix-tures, articles) are clean
	Waste image is undesirable	Sustainability image is highly desirable: produced from recycled material
	Something to get rid of	Something to buy
	General public not interested in waste	General public is interested in materials or articles

When waste turns into a product, REACH and other product regulation start to apply. If the material contains SVHCs above the limits set, authorisation may apply. Examples are for instance recycling of soft PVC that contains DEHP. Other examples are plastics that contain POP-BDEs, or polystyrene that contains HBCDD. Figure 6 illustrates the decaBDE concentrations measured in a ELV and WEEE waste stream in the Netherlands (IVM/IVAM, 2013) and indicates that the place in the waste stream where samples are collected and the place of the EoW are essential in interpreting the results and may determine whether a product may be marketed or not. Maximum decaBDE concentrations decrease through the waste chain, but for a correct interpretation the total waste mass balance should be taken into account. Considerable percentage of the initial material is incinerated (IVM/IVAM, 2013).

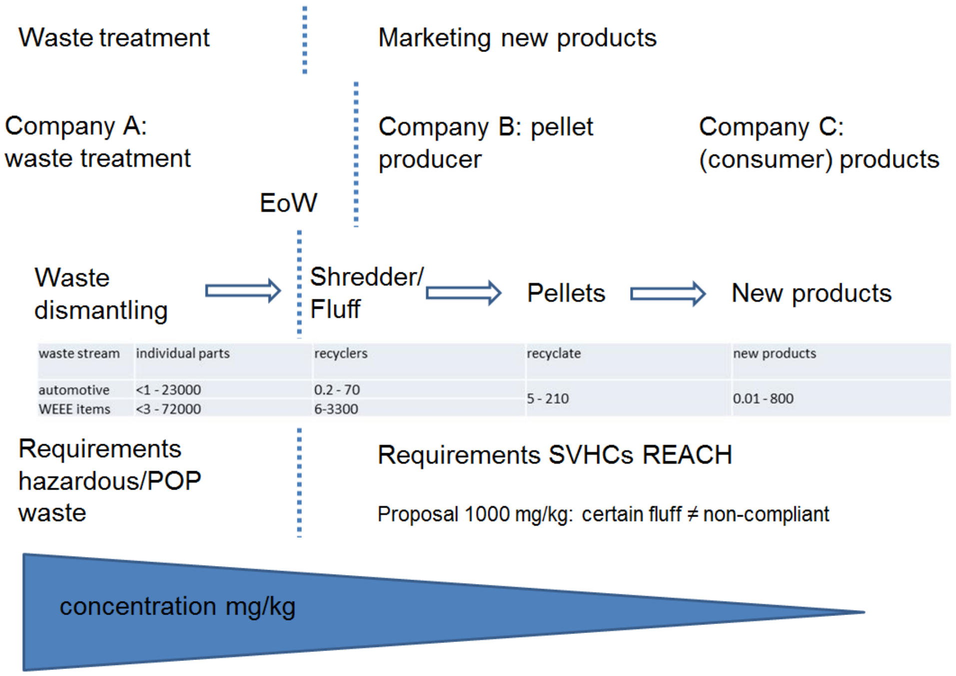

Figure 6. Variation in DecaBDE-concentrations in various stages of the ELV- and WEEE waste chain and a possible EoW position. DecaBDE-data from IVM/IVAM (2013). The EoW determines whether the waste legislation applies or the REACH Regulation.

Labelling.
Some interviewees put forward the use of a passport for raw materials, which may resemble the obligation within REACH, where the producer has to follow their substance until downstream users. The experiences suggest that this is easier in theory than in practice, specifically when articles become waste. Applicability is more realistic in large items such as pipes or window frames, than in small items, such as spare parts. The waste treatment company may know that certain product may contain certain SVHCs, but does not have the knowledge in which specific products these substances have been applied. Furthermore, from the interviews could be concluded that waste material is disassembled and that, although it changes from mixed waste to pure polymer (see Figure 1), it moves in practice through a network of

different international waste treatment companies (see Figure 2). Thus, labelling or a passport may be of use at the beginning of the disassembly, but is useless further in the chain where the material is mixed from different incoming streams, grinded and compounded.

4 Conclusions

This report focused on possible challenges observed by the recycling sector regarding the handling of plastic waste streams with SVHC's. Examples of SVHCs can be found among the group of flame retardants, plasticisers and stabilisers. Relatively speaking, there is a lot of information available on the possible presence of SVHC's in plastics. Less is known on other waste streams like e.g. alloys (lead), glass (lead), and paper (mineral oils) and more research is recommended to map SVHC's in those waste streams too.

The interviews conducted in the context of this study led to conclude that there is uncertainty in the sector regarding the interpretation of the Waste Framework Directive and the REACH Regulation. This particularly involves identification of the End of Waste, i.e. *when does the REACH Regulation start to apply*. The interviewees indicate that the processes under REACH require a relatively high level of knowledge on the composition of the recycled material and a certain degree of continuity of this composition over time. This knowledge base is higher than the knowledge required for continuing treating the material as waste and their regulation under the Waste Framework Directive. Though the requirements and costs of REACH are indicated as challenging, an incentive for recyclers to register their material as secondary resource is that product manufacturers are hesitant to use waste as resource for their products. Product manufacturers much better like secondary resources labelled as 'recycled material' primarily for marketing reasons.

With regard to SVHCs (or hazardous substances in general), the most important uncertainty relates to what substances to expect in which waste streams, and directly related to this, how to deal with these to create a sustainable market for recycled material. This suggests that in addition to reaching consensus on EoW for plastics at EU level, there is a need to increase knowledge on SVHC-containing wastes (and waste, free of SVHCs) and a better understanding on possible market perspectives of recyclate that does contain SVHCs above the concentration limit for Authorization under the REACH Regulation.

To gain a better understanding of the possible market perspectives of SVHC containing waste a policy discussion is needed on the wish to reduce exposure to hazardous substances as much as possible and the practical implications in terms of costs and benefits of keeping, removing or destroying the SVHCs already present in the technosphere. Several elements that were brought forward by the interviewees to be discussed are:

- Content of SVHCs in recycled materials, what is acceptable and may maximum limits be different for legacy substances compared to virgin material?
- Emission of SVHCs from recycled materials, what is acceptable and may maximum limits be different for legacy substances compared to virgin material?
- Technical and economic feasibility to remove SVHCs from the material.

- Technical and economic feasibility to separate SVHC containing waste at an early phase of the waste treatment process.

Such a discussion needs insight in the risks of the SVHCs as well as insight in the possibilities and impossibilities to remove them from the waste stream from a practical point of view. Another important topic that should be addressed is the balance between protection of men and environment on one side and the need to increase sustainability in terms of resource efficiency, a reduced demand for raw materials and reduction of e.g. CO2 emissions. At this moment, there is only little experience in ‘acceptable’ recycling possibilities for waste that contains SVHCs. The one example of cadmium containing PVC suggests that authorization may be granted when exposure to men and the environment can be controlled.

From the interviews is furthermore concluded that targeted recycling of SVHC-containing materials and separation of SVHCs from the waste stream may be most effective when SVHC-containing items are identified in one of the first steps of the waste treatment process, preferably before a more homogeneous mixture is being created. Several interviewees indicate that the recyclate produced to date is only a little lower in unit-costs than virgin material. Further investment in the upfront separation of SVHC-containing waste from SVHC-free waste may therefore easily increase the unit-costs for recyclate such that it may no longer compete with virgin material. Because of the costs involved and of practical reasons in early separation of waste streams, separation of different materials is often only happening at a later stage of the waste recycling processes. Also, monitoring of the possible presence of SVHCs is primarily done at later stages when the polymer is grinded for further processing steps. This is partly done for technical reasons. The practical aspect is that the incoming material is often so divers of composition and origin that it is far too costly and time consuming to monitor every single article or piece of material. A modern car consists of about 30,000 parts[18] which are partly removed (see chapter 2.6), the remainder is shreddered. There is currently no incentive to change this situation for many types of wastes. For those wastes for which there is a regulation (like for PCB containing capacitors and transformers) experiences show positive in the early separation of these materials from the waste stream, in case the items containing hazardous substances can be easily identified. Incentives are suggested by the interviewees as a potential model to stimulate more intensified upfront separation given the current waste treatment practice. An example hereof is the mandatory removal of certain SVHC-containing parts from electronic waste.

However, one important challenge in dealing with plastic waste involves finding the right business model. Ideally, upfront separation should result in higher value recyclate and reorganization of the waste chain in close collaboration of all its actors may be considered to build a more sustainable waste treatment process. One practical example of such a reorganization that is being implemented already for PET bottles is to close loops between product manufacturers, waste collectors and

[18] http://www.toyota.co.jp/en/kids/faq/d/01/04/ download 08042017

recycling companies to keep pure waste streams, keep the costs down as much as possible and facilitate high value recycling. From the interviews is deduced that making the recycling process profitable depends on the following factors: first, there should be a market. A current challenge is that product manufacturers tend to specify "SVHC-free" resources from their supplier. Marketing of SVHC containing materials is an issue and a specific market should be identified first before investments will be made into the application for authorisation and the start of recycling of this type of waste. Second is the volume of the recycled material. This should be sufficiently high and constant in composition to make application for authorization for the specific waste stream and the intended use economically interesting.

Upfront separation is however only possible when the specific items are known to contain SVHCs. Plastics that have a long service life may contain SVHCs which have already been phased out in products with a shorter life cycle. Based on the type of use, plastics used in automotive, construction and electronics may be expected to typically contain higher levels of SVHCs. However, a comprehensive overview of material compositions would facilitate identification of SVHC containing materials at an early stage of the waste phase. Polymer Comply Europe, the European branch organisation for polymers runs a database in which information on SVHCs and plastics has been incorporated. Such information may be employed to alert recyclers to certain SVHCs that could be present in the waste they recycle. Making such information available at European level is considered by the interviewees as a step forwards in facilitating early waste separation into SVHC-rich and SVHC-poor waste streams. To some extent, developments in this direction are already ongoing in the form of R-SDSs: safety datasheets for recycled materials. For plastics with a long service life, it may be of importance to keep record of historical abundances of SVHCs that may have been substituted in new plastics but may still be present in waste streams. The Dutch Federation of Rubber and Plastics Industry NRK indicated that their European sister organisation Polymer Comply Europe[19] runs a database in which information on SVHCs and plastics has been incorporated. Such information may alert recyclers to certain SVHCs that may be present in the waste they recycle. Similar information may be made available through the R-SDSs (Safety Data Sheets for recycled material).

To conclude, challenges of the sector involving the recycling of waste potentially containing SVHCs centre around:

1) uncertainties in regulatory requirements (which legislation applies, what should be done?)
2) uncertainties that relate to the materials' composition (does the material contain SVHCs or possibly substances that will be identified as SVHC in the years to come?)
3) the economic feasibility of the process (how to keep recycling of waste competing with virgin material?)
4) the technical feasibility of screening and separation

[19] http://www.polymercomplyeurope.eu/pce-services/sds-r-tool-service

In addition to these, also emotional factors with regard to marketing of waste, products made of waste and products containing SVHCs are of influence on challenges the sector is facing dealing with SVHCs in waste.

A number of items identified during the interviews and laid down in this report are subject of recent or current RIVM studies. These studies focus partly on so-called Dutch ZZS substances, which can be seen as Dutch substances of very high concern. A description of these substances is provided in Wassenaar et al (2017 a, b). The studies recently or currently being carried out comprise:

a. Sight on potential ZZS substances in various waste streams (Wassenaar et al, 2017a)
b. Concentration limits for ZZS in Dutch waste streams (Wassenaar et al., 2017b)
c. Guidance for the risk analysis of ZZS substances in waste streams to facilitate the Dutch National waste management plan (in progress)[20]
d. Safe Loops project where both safety and sustainability aspects, such as CO2 reduction and reduction in raw materials usage, are considered in an integrated weighing framework (in progress)

[20] http://rwsenvironment.eu/subjects/from-waste-resources/national-activities/national-waste/

5 Acknowledgements

We acknowledge the input from Stefan Cabri of the trade association of certified automobile, motorcycle , truck and related vehicle dismantlers STIBA, Jolanda Neeft of the Dutch Federation of Rubber and Plastics Industry NRK, Roger Loop of the organisation for plastic pipe systems in the Netherlands BureauLeiding, the Trade association Employers Metal – Elektro FME, Edmar Meuwissen of the European manufacturors of Expanded PolyStyrene EUMEPS and Leon Urlings of the Waste Management Association Vereniging Afvalbedrijven.
We further thank Jan-Hein Stiens of Coolrec/PHB, Marcel van der Veer of ARN BV, Ton van der Giessen of Van Werven Recycling, Eric Schutjes of the Dutch Federation of Rubber and Plastics Industry NRK/Recycling, Tinus de Lange of WAVIN, Eelco Smit of Philips and Bert Bolink and Jur Zandbergen of Veolia Polymers NL B.V. for providing information on waste treatment, recycling or producing recycled products within their companies. Charles Bodar and Nicole Janssen critically reviewed the manuscript, whereas the latter also proposed changes in Figure 1.

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Annex 1. Discussion note on recycling and REACH

Dutch contribution to CARACAL 12: Agenda point 8_2 NL Discussion note Recycling and REACH

Introduction

The NL CA-REACH would like to draw Caracal's attention to apparent difficulties it has observed regarding the impact of authorisation under REACH to Recycling activities. We have observed that REACH may have a significant negative impact on recycling activities, which seems to be of such relevance that discussing this topic at Caracal 12 is warranted.
The issue at stake can be explained in a relatively simple manner:
In accordance with Article 56 REACH the recycling of any waste material containing a substance included in Annex XIV for which the sunset date has passed, is assumed to be a prohibited use of that substance unless an authorisation has been granted for that use.
This authorisation requirement could endanger the aims and targets of the European waste policy, and currently industry stakeholders are ringing the alarm bell because they fear it will shortly lead to a stop of many European recycling activities, preventing the EU to move towards a 'Recycling Society' or Circular Economy that is resource efficient.
The Netherlands CA would therefore welcome Caracal's views on this issue, and a brief description of the issue is given below, together with some key questions for discussion.

Authorisation and Recycling

In accordance with article 56 REACH, a manufacturer, importer or downstream user shall not place a substance on the market for a use or use it himself if that substance is included in Annex XIV, unless authorisation for that use has been granted or the use(s) of that substance on its own or in a mixture or the incorporation of the substance into an article for which the substance is placed on the market or for which he uses the substance himself has been exempted from the authorisation requirement in Annex XIV itself.

Recyclers of materials like paper, plastics and even metals, have (pre-) registered as appropriate the substances in recovered materials, for those situations where they must be considered to be manufacturers in accordance with the Guidance on waste and recovered substances (version 2, May 2010). So they have found solutions for the (pre-) registration requirements under REACH. However they are now faced with authorisation requirements, which appear to be a serious impediment for continuation of European recycling activities.

Based on the presumption that without an authorisation, any waste material containing a substance included in Annex XIV for which the sunset date has passed, cannot be recycled in the EU, serious difficulties have arisen. Recovery is clearly a use as defined in REACH. Hence for any Annex XIV substance that can be found in a waste stream that is recovered by recyclers, the recyclers need to apply for an authorisation for recycling of such waste streams.

However, since the candidate list is expanding and Annex XIV is now regularly being amended by adding more substances to it, the recycling industry is faced with a growing number of chemical substances appearing in Annex XIV that can be found in varying concentrations in the waste streams, which are sources for their recovery activities. So they face a moving target.
In view of the cost involved with compiling and submitting authorisation dossiers for each of these substances, as well as the workload for applying for authorisations, the recycling industry states that the authorisation requirements under REACH will eventually lead to a situation that waste can no longer be recycled anymore in Europe, both from an economic perspective as well as from a workability point of view. In particular the fact that most recyclers do not possess the chemical data needed for an authorisation dossiers (hence they need to buy the data from third parties) makes their recycling activities economically unviable.

Urgency
In the Netherlands, recycling industry has informed authorities that at this moment there are already 8 substances included in Annex XIV that may occur in plastic waste (flame retardants, plasticizers and colorants) for which authorisation is required in order to continue recycling of such waste. Mutatis mutandis the same applies for metal recycling (i.e. chromium compounds), paper recycling (i.e. inks), glass recycling (i.e. lead) and other waste materials which are recycled on a large scale and contain SVHC or potential future SVHC substances that may end up in Annex XIV. Numerous substances were used in the past – the so called legacy chemicals – and a substantial number of these substances may in the near future end up in Annex XIV, making recycling increasingly costly and basically unworkable. By way of illustration two position papers of the Dutch and the EU plastic recycling industry have been annexed into this note. The NL CA does not necessarily agree with all elements of these position papers, but the sense of urgency they describe, illustrates the scope of the issue.

An application for authorisation must be submitted at least 18 months before the sunset date of the substance which means that already before 21 June 2013 the first authorisation applications need to be submitted for recycling activities in the field of plastic recycling.
Since the recycling industry has now become aware of this burden, it needs to make choices about the cost of investing in authorisation applications versus the benefits of continued recycling activities. However it appears that the cost don't outweigh the benefits, which may eventually lead to a stop of many European recycling activities. Since the issue has now been brought to the attention of authorities, the NL CA would like to invite Caracal members to discuss to which extent they recognize the problem and whether Caracal members consider there is a need to address that problem.

Questions
1. Do Caracal members agree that waste recycling activities in Europe are important and should be continued? If so, do they consider this also to be the case for recycling of waste streams containing various

concentrations of chemical substances included in Annex XIV of REACH?

2. Do Caracal members agree that for any substance included in Annex XIV that occurs in waste material that is being recycled, an authorisation is needed for such recycling after the sunset date for that substance has passed? If so, do Caracal members then recognize the (potential) size of the difficulties as described in this note, as being of such importance that the issue needs to be addressed at EU-level in order to facilitate continued waste recycling in Europe?
3. In case the need to find solutions for continued waste recycling activities is recognized, do Caracal members find it feasible and justifiable to consider options such as exempting recycling activities from authorisation under conditions further to be identified?

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