KEMI
Swedish Chemicals Agency

Review and analysis of exemptions under EU law for substances of very high concern in recycled material

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KEMI
Swedish Chemicals Agency

The Swedish Chemicals Agency is supervisory authority under the Government. We work in Sweden, the EU and internationally to develop legislation and other incentives to promote good health and improved environment. We monitor compliance of applicable rules on chemical products, pesticides and substances in articles and carry out inspections. We review and authorise pesticides before they can be used. Our environmental quality objective is A Non-toxic Environment.

Article number: 511 375.

Preface

This study was commissioned by the Swedish Chemical Agency and conducted by Ramboll Environment & Health. The study was initiated as part of an ongoing dialogue between the Swedish Chemicals Agency and the Swedish Environment Protection Agency regarding how to increase material recycling without recirculating substances of concern. Recent discussions have focused on how to manage recycled material that may contain hazardous substances that are subject to new restrictions in the chemicals legislation.

The aim of this report was to (i) provide an overview of any exemptions made in chemicals legislations for substances of very high concern in recycled material, (ii) identify reasons and arguments for adopting such exemptions and (iii) examine to what extent the exemptions have been utilised by industry.

The scope and the focus of the report has been defined by the Swedish Chemicals Agency and the Swedish Environmental Protection Agency, but the literature review and data collection have been conducted by Ramboll Environment & Health. There has been a continuous dialogue between the consultant and the agencies throughout the project period. However, the analysis, reasoning and conclusion presented in this report is the sole responsibility of the authors, Ramboll Environment & Health. Any opinions and conclusions expressed in this report are those of the consultant and do not necessarily reflect or represent the views or opinions of the Swedish Chemicals Agency and/or the Swedish Environmental Protection Agency.

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Glossary

AoA	Analysis of alternatives
BDEs	Brominated diphenyl ethers commonly used as flame retardants.
CCA	Copper, chromium, arsenic
CEAP	Circular economy action plan
CLP Regulation	Regulation on classification, labelling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006
CLRTAP	Convention on Long-Range Transboundary Air Pollution on Persistent Organic Pollutants
CMR	Carcinogenic, mutagenic or toxic for reproduction
CPW	Chemical, product and waste legislation
CSR	Chemical safety report
DDT	1,1,1-trichloro-2,2-bis (4-chlorophenyl)ethane. A toxic, chlorinated insecticide that was amongst the first 12 POPs to be regulated under the Stockholm Convention.
decaBDE	Bis(pentabromophenyl) ether. Brominated flame retardant mainly composed of the congener BDE-209 primarily used in electrical and electronic equipment.
DEHP	Bis(2-ethylhexyl) phthalate. The most common member of the class of phthalates, which are used as plasticizers.
DoCs	Declarations of conformity
EAP	Environmental Action plan
EC	European Commission
ECHA	European Chemicals Agency
EDC	1,2-Dichloroethane. A solvent, commonly known as ethylene dichloride. The most common use is in the production of vinyl chloride.
EEE	Electrical and electronic equipment
EERA	European Electronics Recyclers Association
EGARA	European Group of Automotive Recycling Associations
ELV	End of Life Vehicle
EPPA	The European PVC Window Profile and related Building Products Association
EPS	Expanded polystyrene. An expanded foam version of polystyrene used in a variety of applications due to its light weight and isolating properties.
EU	European Union
EuRIC	The European Recycling Industries' Confederation
FAQ	Frequently asked questions

HBCDD	Hexabromocyclododecane. A brominated flame retardant mainly used in rigid insulation panels/boards made of expanded or extruded polystyrene.
HIPS	High Impact Polystyrene
LPCL	Low POP Concentration Limit
PBDEs	Polybrominated Diphenyl ether. A class of organobromine compounds used as flame retardants.
PBT	Persistent, bioaccumulative and toxic
PBT	Polybutylene terephthalate is a thermoplastic engineering polymer that is used as an insulator in the electrical and electronics industries
PCB	Polychlorinated Biphenyls. Group of toxic aromatic chlorinated organic compounds used in industrial applications. Amongst the 12 first POPs to be regulated under the Stockholm Convention.
POP	Persistent organic pollutants
POPs regulation	Regulation (EC) No 850/2004 on persistent organic pollutants. Superseded by Regulation (EU) 2019/1021 on persistent organic pollutants (recast).
PUR	Polyurethan. PUR are used in manufacturing of high-resilience foam seating, rigid foam insulation, durable elastomeric wheels, carpet underlay, hard-plastic parts etc.
PVC	Polyvinylchloride. Widely used synthetic plastic polymer available in both a rigid form (used in construction pipe and profiles as well as bottles and non-food packaging) and flexible form (used in plumbing, electrical cable insulation, flooring and may replace the use of rubber).
REACH	Regulation (EC) No 1907/2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals
Recovinyl	Recovinyl is an initiative by the European PVC value-chain aimed at facilitating PVC waste collection and recycling under the Voluntary Commitments of Vinyl 2010 and now VinylPlus®
RMOA	Risk management and options analysis
RoHS	Directive 2011/65/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment
SEA	Socio-economic analysis
SVHC	Substances of very high concern, which are defined in this report as substances fulfilling the criteria of Article 57 (a) through (f) and Annex XIII of the REACH Regulation
TEPPFA	The European Plastic Pipe and Fittings Association
TFEU	Treaty on the Functioning of the European Union
UTC	Unintentional Trace Contaminants
vPvB	Very persistent and very bioaccumulative
WEEE	Waste electrical and electronic equipment
WFD	Waste Framework Directive, Directive 2008/98/EC on waste

Summary

In the REACH Regulation, POPs Regulation and RoHS Directive, there are in a few cases exemptions of restricted substances in recycled materials. In this project, the arguments for adopting these exemptions and their impact on recycling have been analysed. First a scoping exercise was performed to identify exemptions. Thereafter, selected exemptions and the argumentation associated with them were analysed. Finally, an in-depth analysis and a stakeholder consultation was performed, also assessing the use and effects on recycling for three exemptions concerning DEHP, cadmium and BDEs.

DEHP is a plasticiser primarily used in PVC. In this project, the exemption for recycling DEHP containing PVC was studied as a case of a substance listed in Annex XIV of REACH. In 2013, three companies applied for authorisation for using DEHP-containing PVC waste. Only one of these three companies completed the re-application process in 2019. Although the companies applied in a consortium in 2013, each of the three companies used a company specific business model. The main arguments, both for the first and second application, were economical and lack of alternatives. The companies not reapplying for authorisation states that this was mainly due to their business turning out to be unprofitable due to lack of demand for recycled materials. One of the companies was liquidated as an effect of this.

Cadmium has been used as a stabiliser in rigid PVC products, most notably window profiles and other construction related profiles. The use of cadmium in PVC products was restricted under Annex XVII to REACH in 2011. An exemption to the restriction was included for the use of recovered PVC with a maximum concentration of 0.1%. The arguments used for the implementation of the exemption were environmental. PVC industry stakeholders seem to have differing views on whether the adopted exemption has led to an increase in PVC recycling. The general association for PVC recycling is of the opinion that the current increase in recycling would not have been possible without the exemption. Other associations argue that the exemption as such did not lead to an increase of PVC recycling but rather enabled the continued use of recovered PVC containing cadmium.

Polybrominated diphenyl ethers (PBDEs) have been used as flame retardants primarily in flexible PUR foams and in plastic casings for electronics. Certain brominated diphenyl ethers (BDEs) were prohibited after a listing in the Stockholm Convention in 2009 and subsequently in the EU POPs Regulation. An exemption was implemented in 2010 allowing the then regulated BDEs in recycled material in concentrations below 0.1%. The POPs Regulation was recast during 2019 and the recycling exemptions for brominated flame retardants is no longer included in the new Regulation. The arguments and documentation behind the adoption of these exemptions is scarce but seems to be based on expected technical difficulties and the effects that the ban would have on the continued recycling of materials. The ELV recyclers stated that the recycling exemptions had not been utilized mainly as the PUR foams in vehicles were not recycled but incinerated or deposited in landfills. The WEEE recyclers conveyed a similar opinion stating that the recyclers already complied with the lower concentrations of PBDEs set in the RoHS Directive that were already in force at the time of the ban of BDEs in the POPs Regulation. Furthermore, information suggests that export of WEEE outside EU may have made the use of a recycling exemption unnecessary.

In conclusion, this analysis shows that both the procedures as such and the reasoning behind the adoption of the investigated exemptions vary considerably. The arguments for implementing the different exemptions include technical, economic, environmental, political and human health. Furthermore, to what extent the different exemptions have been utilised differed but also varied depending on e.g. the sector or company business model.

Sammanfattning

Både inom REACH-förordningen, POPs-förordningen och RoHS-direktivet finns det i ett fåtal fall undantag för återvunnet material som innehåller reglerade ämnen. I detta projekt undersöktes skälen till att införa dessa undantag och hur undantaget påverkat berörda aktörer inom återvinningsbranschen. Först identifierades vilka undantag som finns inom respektive lagstiftning. Därefter undersöktes skälen för att införa undantag i några utvalda fall. Slutligen genomfördes en mer djupgående analys som också omfattade en intressentdialog. I den fördjupade analysen gjordes en utvärdering av hur tre utvalda undantag utnyttjats, gällande DEHP, kadmium och BDE, och vilka effekter som dessa fått för återvinningsbranschen.

DEHP är en mjukgörare som främst används i PVC-plast. I detta projekt användes DEHP som fallstudie för tillståndsprocessen för ämnen listade i bilaga XIV till REACH. År 2013 ansökte tre företag om tillstånd för återvinning av DEHP-innehållande PVC-avfall. Endast ett av dessa tre företag slutförde en andra ansökan år 2019. De viktigaste argumenten både vid den första och den andra ansökan var ekonomiska skäl och att alternativ saknades. De företag som inte ansökte om förnyat tillstånd uppgav att anledningen var olönsamhet. Ett av företagen avvecklades på grund av detta.

Kadmium har använts som stabilisator i styva PVC-produkter, särskilt i fönster och andra byggnadsrelaterade profiler. Användningen av kadmium i PVC-produkter begränsades år 2011 i bilaga XVII till REACH. Användning av återvunnen PVC med en maxkoncentration av 0,1% undantogs från begränsningen. Miljömässiga skäl låg till grund för att införa undantaget. Kontaktade representanter i PVC-industrin har olika uppfattningar huruvida undantaget har inneburit en ökad materialåtervinning av PVC eller ej. Den övergripande branschorganisationen för återvinning av PVC anser att den nuvarande ökningen av återvinning inte skulle ha varit möjlig utan undantaget. Andra, mer nischade återvinnings-organisationer, anser att undantaget i sig inte ledde till en generell ökning av PVC-återvinningen, men möjliggjorde en fortsatt användning av återvunnen PVC med kadmium.

Polybromerade difenyletrar (PBDE) har använts som flamskyddsmedel främst i flexibel PUR-skum och i plasthöljen för elektronik. Vissa bromerade difenyletrar (BDE) förbjöds efter att de listats i Stockholmskonventionen 2009 som därefter införlivades i EU:s POP-förordning. I ett undantag som infördes år 2010 tilläts halter upp till 0,1% BDE i återvunnet material. Undantaget upphörde år 2019 när POPs-förordningen reviderades. Argumenten och dokumentationen i samband med införandet är knapphändiga, men verkar ha baserats på förväntade tekniska svårigheter och de effekter som förbudet skulle kunna få på återvinningsgraden av material. Kontaktade återvinningsföretag inom fordonsbranschen, framförde att undantaget för återvunnet material inte utnyttjats för att PUR-skum i fordon i första hand förbränns eller deponeras. Återvinnare av elektrisk och elektronisk utrustning meddelade även de att undantaget för återvinning inte utnyttjats då aktörerna i branschen redan uppfyllde de striktare haltkraven av PBDE som fanns i RoHS-direktivet vid tidpunkten då förbudet i POPs-förordningen infördes. Dessutom indikerar de europeiska återvinnarna att tidigare export av WEEE till länder utanför EU kan ha minskat behovet av att nyttja undantaget.

Sammanfattningsvis visar denna analys att både processen som sådan och den tillgängliga dokumentationen av skälen till att införa undantagen varierar avsevärt. Skälen till att införa de olika undantagen omfattar såväl tekniska, ekonomiska, miljömässiga, politiska som hälsomässiga skäl. Vidare indikerar analysen att utnyttjandet av undantagen skiljer sig åt mellan ämnena, men också att det kan variera beroende på t.ex. bransch eller företagens affärsmodeller.

1 Introduction

Interested parties, such as authorities, non-governmental organizations, sector associations and academia have for several years been discussing how material recycling could increase without recirculating substances of concern. Some hazardous substances, such as substances of very high concern (SVHCs), pose such a serious risk to man and/or environment that they should as far as possible be phased out of society. At the same time, many of these substances have been used in large volumes and are present in materials built into society. These large quantities of materials could be seen as potential resources in a new life cycle if they could be properly recovered. Depending on the different streams of materials, the substances can also be found in newly produced materials, especially in imported materials and articles.

More recently, the regulatory discussions have more often come to deal with how recycled materials should be treated when new restrictions of chemicals are introduced. In practice, different factors need to be considered, such as the risk of exposure to hazardous substances and the possibility of recycling a material to save resources or reduce the climate impact.

In this context, this report aims to review the exemptions allowing the recycling of hazardous substances under three European chemical legislations. The legislations in scope are:

- the REACH Regulation (EC No 1907/2006),
- the former POPs Regulation (EC No 850/2004) and
- the RoHS Directive (2011/65/EU)

The aim of this review was to:

- identify the recycling exemptions under the three legislations considered in this project.
- analyse selected exemptions for recycling material containing substances of very high concern.
- identify the arguments or reasoning used to implement these exemptions in the law
- investigate if and to what extent these exemptions has been used by the recycling industry in the EU, and
- if possible, assess what impact the exemptions have had on recycling of the substance of concern.

2 Background

In December 2019, the European Union launched the European Green Deal (EC 2019b), which includes measures accompanied with an initial roadmap of key policies to become more sustainable. This new growth strategy aims to “transform the EU into a fair and prosperous society, with a modern, resource-efficient and competitive economy where there are no net emissions of greenhouse gases in 2050 and where economic growth is decoupled from resource use”.

Even before the European Green Deal was adopted, the European Union had committed itself to two important EU environmental aims. Firstly, the aim to protect human health and ensure non-toxic material cycles and secondly the ambition to transition to a resource efficient circular economy. These aims are in line with the two priority objectives presented in the most recent 7th Environmental Action Plan (7th EAP)(EP 2020):

1) the realisation of a resource-efficient, green and competitive low-carbon economy; and
2) to safeguard the EU citizens from environment-related pressures and risks to health and well-being.

As a step towards increased resource efficiency, the EU legislative framework on waste has been revised lately. The updated version entered into force in July 2018 and sets clear targets for reduction of waste and promotes waste management and recycling.

The balance between the objectives expressed in the 7th EAP has been further substantiated in the EU´s circular economy action plan (CEAP) presented in 2015. The circular economy action plan, in addition to its focus on increased recycling, also points out the issue of substances of concern in products and waste (EC 2015). Depending on the type of material being recycled, and the recycling process, there may be different challenges. The general aim to increase the rate of recycling may result in recirculation of hazardous substances present in the materials. Due to the occurrence of hazardous substances in waste and the associated difficulties with removing these substances, there are occasionally exemptions or derogations laid down in the EU chemical- or product legislations to not rule out recycling.

In its Green Deal roadmap, the European Commission highlights some of the main challenges concerning the presence and persistence of hazardous substances in recycled materials. In this document and subsequent communication on the interface between chemical, product and waste legislation (CPW interface), several issues are identified. One of these issues is that information on presence of substances of concern is not readily available to those who handle waste and prepare it for recovery (EC 2018). It also emphasises the problems associated with waste containing substances that are no longer allowed in new products, so called legacy substances.

In line with the CPW communication, the European Commission and other EU agencies have taken various steps to address the challenges identified under the CPW interface policy track. Most notably, a study was published concerning the development of an evidence-based approach as support to regulators when assessing how to manage the presence of substances of concern in recycled materials (RIVM_Ramboll 2019). In addition, the European Chemicals Agency (ECHA) is in the process of establishing a new database on the presence of substances of very high concern in articles for waste treatment operators and consumers (SCiP-Database), which will be in use from January 2021.

The importance of circular economy is also highlighted in the upcoming, not yet adopted, 8th EAP, that will give political guidance for the EU's environment and climate change policies for the period 2021 – 2030. This upcoming Environmental Action Plan foresees a new

circular economy action plan and a long-term strategic framework, including a common vision, for a circular economy (EU_Council 2019).

2.1 EU legislative framework and recycling exemptions

As described above, the EU waste, chemicals and products law contains various provisions for hazardous substances which aim to enable recycling. In the following sections, the legislative background for the selected EU regulations in scope of this report are presented.

2.1.1 REACH Regulation

Before EU adopted its new chemical legislation Regulation (EC) No 1907/2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), authorities were responsible for evaluating chemical safety. Chemical producers on the other hand were only obliged to provide information in case an evaluation by authorities had proven gaps in knowledge about the chemical or if there was evidence of potential harm to the environment and/or human health. A special feature of REACH is that the burden of proof of harmlessness or the obligation to provide information lies with the manufacturer and importer placing the substance on the market. This concept is called "no data, no market" and is fundamental to REACH.

The REACH Regulation relies on four main procedures: registration, evaluation, restriction and authorisation of chemical substances. Following registration by industry and evaluation by the competent authorities, restriction and authorisation are the available instruments used to protect human health and the environment from unacceptable risks posed by chemicals. Only substances for which usage is restricted (substances included in Annex XVII) or need to be authorised (substances included in Annex XIV) are to be considered in the present project, as only those would require an exemption for (the level of) hazardous substances in recycled materials.

The authorisation procedure is of interest for this project, as the arguments used in an application for authorisation are built on pre-defined aspects e.g. economic, social or environmental considerations. Those arguments are also valid for exemptions for recycling/recycled material. Authorisation is a lengthy, complex and costly process, in which the burden of proof for justifying continued use of substances of very high concern (SVHC) lies with the companies.

The term SVHC is crucial in this context, as authorisation applies only to these substances. Properties which generates serious and often irreversible effects on human health and the environment are used to identify substances as SVHC. The criteria for identification are:

- CMR: substances fulfilling categories 1A or 1B as carcinogenic, mutagenic or toxic for reproduction according to the CLP Regulation
- PBT/vPvB: substances which are persistent, bioaccumulative and toxic (PBT) or very persistent and very bioaccumulative (vPvB) according to Annex XIII of the REACH Regulation;
- on a case-by-case basis, substances which give rise to an equivalent level of concern as CMR or PBT/vPvB substances (endocrine disruptors, or respiratory sensitizers and substances with specific target organ toxicity after repeated exposure).

The aim of identifying a substance as SVHC is to gradually replace it with a safer substance or technologies where technically or economically viable alternatives are available.

Authorisation is only granted if the application fulfils at least one of the following scenarios:

1. Adequate control: Applicants must show that the risk from using the substance is adequately controlled.
2. Socio-economic benefits outweigh risks and there are no suitable alternatives: Where there are suitable alternatives the application must also include a 'substitution plan'.

In the authorisation process, the applicant prepares the following documentation as basis for the application:

- chemical safety report (CSR)
- analysis of alternatives (AoA)
- socio-economic analysis (SEA) is required for non-threshold substances and recommended in any case.

The preparation of these reports requires a substantial amount of data, covering several categories of impacts. The following aspects are considered in the authorisation process; human health risks, environmental risks, economic impacts and social impacts.

The specific recycling activities, which are in the scope of this report, are considered under the environmental risk assessment where the impacts on waste production are addressed (ECHA 2011). The authorisation process for the plasticiser bis(2-ethylhexyl) phthalate (DEHP) has been used as a case study to examine the mechanism, rationale and consequences for a recycling exemption in this report.

Within the legal framework of REACH, restrictions are intended to manage risks that are not adequately addressed by other procedures of REACH, including authorisation. Thus, restrictions are not limited to SVHCs and their specific set of criteria. Restrictions are normally used to limit or ban the manufacture, placing on the market (including imports) or use of a substance, and can impose any relevant condition (technical measures or specific labels). The restriction of cadmium (entry 23 of Annex XVII) is an example of such a limited restriction. Cadmium is used as an example of how recycling exemptions may be implemented in a restriction under REACH. The burden of proof for justifying a restriction lies with ECHA or a Member state. However, the burden of proof for justifying exemptions lies mainly with the industry.

2.1.2 POPs Regulation

Regulation (EC) No 850/2004 on persistent organic pollutants (POPs Regulation) was implemented in EU 2004 to meet the obligations required by two conventions. These are the international Stockholm Convention on Persistent Organic Pollutants and the POPs-protocol under the regional Convention on Long-Range Transboundary Air Pollution on Persistent Organic Pollutants (CLRTAP).

Persistent organic pollutants (POPs) are a group of organic substances that give rise to considerable environmental and human health concerns. This is due to their specific physico-chemical properties (for example stability and inertness). For a substance to be considered as a POP, it must be persistent in the environment, bio accumulate in the food chain, have the potential for long-range environmental transport and indicate adverse toxicological effects.

Due to international developments the POPs Regulation has been amended several times. For reasons of clarity and consistency with other relevant Union legislative acts and due to forthcoming amendments, it has been recast and the current legal reference is Regulation (EU) 2019/1021 (EC 2019d). Initially, twelve POPs were listed in the Stockholm Convention and subsequently in the POPs Regulation. As the Stockholm Convention contains an active process for nominating, reviewing and adding substances, this was followed by the listing of 9

"new POPs" in 2009 and of further listing every meeting of the Parties thereafter. Currently 30 substances are listed in the Stockholm convention and there are more substances nominated to be listed.

The POPs Regulation aims to prohibit, phase out, or restrict the manufacturing, placing on the market and use in both chemical products and articles of the substances listed in the Annex I of the Regulation. To avoid release of these substances, waste consisting of, containing or contaminated by any of the listed substances in Annex IV, shall be disposed or recovered in such a way that the POP content is destroyed or irreversibly transformed. All disposal or recovery operations that leads to recovery, recycling, reclamation or re-use of the substances are prohibited.

The measures described above does not apply when the substances are present as unintentional trace contaminants (UTCs) as further specified in the relevant entries of Annex I or II[1]. The unintentional trace contaminant limit values have been set low enough to rule out any intentional use, i.e. below levels where they can be expected to have any function. In Annex I, the wording unintentional trace contaminant is not used but instead "Specific exemption on intermediate use or other specification". As a manufacturer, importer or distributor of articles, substances or materials, there is a legal obligation to make sure that the articles fulfil the requirements laid down in the Regulation and that the POP content does not exceed any of the specific threshold concentrations listed in Annex I.

For waste, there is a mechanism allowing a certain degree of contamination based on specific concentration limits. Waste containing or contaminated by the substances listed in Annex IV may be disposed or recovered in line with general EU waste legislation's requirements if it does not exceed the concentration limits specified in that same Annex. These concentration limits are generally referred to as Low POP Concentration Limits, abbreviated LPCLs. Waste operators need to ensure that the material they intend to recycle does not exceed the LPCL for each respective substance in Annex IV of the Regulation. If this term is fulfilled, the waste can be recycled by normal procedures.

For example, the entry for Hexabromocyclododecane (HBCDD) under Annex IV to the POPs Regulation lists a concentration limit (LPCL) of 1 000 mg/kg (subject to review by the Commission). This means that a waste stream (e.g. expanded polystyrene (EPS) in building materials) may be recovered if it contains HBCDD in a concentration below this limit value). However, if a material manufactured from recycled EPS containing HBCDD is placed on the market, it shall comply with the unintentional trace contaminant limit value (UTC) of 100 mg/kg (subject to review by the Commission) that apply for articles placed on the market according to Annex I.

After the EU ratified the Stockholm Convention, the listing of substances in the convention and the accompanying measures that follows with it (prohibition, restriction etc.) are legally binding and does not allow for exceptions to be made. This means that an exemption allowing recycled material to contain any of the listed POPs above its UTC level is questionable. The mechanism, rationale and consequences of a recycling exemption of this kind for the in 2010 regulated BDEs are examined in this report.

[1] Annex II is currently empty and does not list any substances.

2.1.3 RoHS Directive

Directive 2011/65/EU lays down rules on the restriction of the use of hazardous substances[2] in electrical and electronic equipment (EEE) to protect human health and the environment, including the environmentally sound recovery and disposal of waste EEE.

The first version of the Directive, also known as RoHS 1, was adopted by the European Parliament and the Council in 2003 (EC 2003). This adoption was accompanied with the adoption of Directive 2002/96/EC on waste electrical and electronic equipment (WEEE) (EC 2011c). On the basis of various important amendments, a new version of RoHS, also known as RoHS 2, was adopted in 2011. This current version of the Directive was subject to amendments in 2015 and was recast in 2017. The RoHS and WEEE Directives are envisaged to apply in a complementary fashion. While RoHS aims to limit the occurrence of certain hazardous substances in the production phase of electrical and electronic equipment, the WEEE Directive aims to prevent or reduce the adverse impacts of the generation and management of waste from electrical and electronic equipment. The WEEE Directive also aims at reducing overall impacts of resource use and improving the efficiency of such use in accordance with the waste hierarchy laid down in the Waste Framework Directive 2008/98/EC.

The provisions of RoHS apply to electrical and electronic equipment (EEE). EEE is defined under Article 3 of RoHS as equipment which is dependent on electric currents and electromagnetic fields to work. It also covers "equipment for the generation, transfer and measurement of such currents and fields and designed for use with a voltage rating not exceeding 1 000 volts for alternating current and 1 500 volts for direct current".

Annex I of RoHS lists 11 categories of EEE that are covered by the Directive. Category 11 (applicable since 2019) concerns other EEE not covered by any of the categories 1-10 and therefore gives RoHS an open scope which covers nearly every type of EEE which fits the definition of Article 3 of the Directive.

Despite the broad scope of RoHS since 2019, some important exemptions to this scope are laid down in Article 2 of the Directive. The paragraphs of this Article list various types of products which, while meeting the definition of EEE, will not fall under the scope of RoHS. These exemptions include, among other things:

- equipment designed to be sent into space;
- large-scale stationary industrial tools; and
- means of transport for persons or goods, excluding electric two-wheel vehicles which are not type-approved.

A central mechanism of RoHS is the restriction of specified hazardous substances as laid down in Article 4(1) of the Directive. This provision determines that Member States shall ensure that EEE placed on the market, including cables and spare parts for its repair, its reuse, updating of its functionalities or upgrading of its capacity, does not contain the substances listed in Annex II:

- Lead (0.1%);
- Mercury (0.1%);
- Cadmium (0.01%);
- Hexavalent chromium (0.1%);

[2] The restricted hazardous substances are listed in Annex II to RoHS and are lead, mercury, cadmium, hexavalent chromium, PBB, PBDE, DEHP, BBP, DBP and DIBP.

- PBB (0.1%);
- PBDE (0.1%);
- Bis(2-ethylhexyl) phthalate (DEHP) (0.1 %);
- Butyl benzyl phthalate (BBP) (0.1 %);
- Dibutyl phthalate (DBP) (0.1 %);
- Diisobutyl phthalate (DIBP) (0.1 %)

It should be noted that the restricted substances must not be contained in EEE placed on the market above a limit value specified per substance in Annex II. The specified limit values are tolerated by weight in homogeneous materials.[3] In accordance with Article 7(a) of RoHS, Member States shall ensure that, when placing EEE on the market, manufacturers ensure that it has been designed and manufactured in accordance with the requirements set out in Article 4 of the Directive.[4]As such, any placing on the market of EEE containing one or multiple of the restricted substances in a concentration above the limit values specified in Annex II RoHS will amount to a violation of the Directive.

2.2 Concepts and definitions

The legal frameworks for chemicals, products and waste contain various concepts and definitions which are named similarly but may have varying definitions or interpretations. In addition, literature and policy documents may refer to such concepts in a less structured and more associative manner. For instance, recovery is sometimes used to refer to recycling. “Product”, “material” and “recyclate” may be used interchangeably. A list of concepts and definitions used in this report is presented in Annex I.

[3] Article 3(20) RoHS defines ‘homogeneous material’ as one material of uniform composition throughout or a material, consisting of a combination of materials, that cannot be disjointed or separated into different materials by mechanical actions such as unscrewing, cutting, crushing, grinding and abrasive processes

[4] Article 4 (1) RoHS states that “ Member States shall ensure that EEE placed on the market, including cables and spare parts for its repair, its reuse, updating of its functionalities or upgrading of its capacity, does not contain the substances listed in Annex II.”.

3 Method

A literature study was conducted in order to review and analyse the exemptions for recycling material containing substances of very high concern regulated under REACH Regulation (EC No 1907/2006), the former POPs Regulation (EC No 850/2004) and the RoHS Directive (2011/65/EU).

First a scoping exercise was performed to identify the recycling exemptions. This provided the foundation for the selection of case studies for further investigation. In the second step, substances were chosen for which the arguments behind the exemptions were analysed. Finally, three substances were chosen for the assessment of the use and effects of the exemptions. The examined substances and a flow chart for the procedure is described in Figure 1.

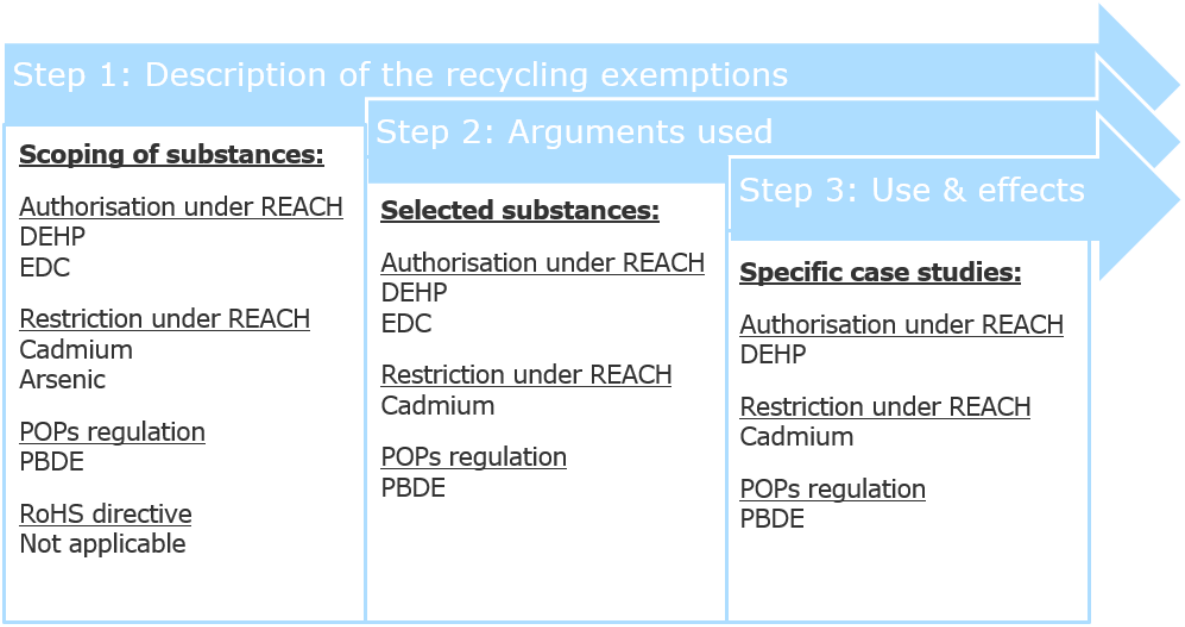

Figure 1. Description of the process to assess the exemptions and substances investigated in this report.

Webpages at relevant agencies and organisations such as European commission, ECHA and the Secretariat of the Stockholm Convention were explored to increase the understanding of the adaptation processes as this was not clearly described for some of the legislations. Personal contact with a representative of the Stockholm Convention contributed greatly to understanding the background to the exemption under POPs Regulation.

The report does not include the exemption for recovered substances in Art 2.7 d of REACH, in which recovery operators who establishes the sameness of a substance with one already registered are exempted from registration of that substance.

The POPs Regulation was recast during 2018/2019 and the recycling exemptions for brominated flame retardants is no longer included in the new Regulation. To be able to investigate how the exemptions have potentially affected the recycling industry, it was more relevant to focus on the exemptions in the former POP Regulation (EC) 850/2004. The recycling exemption for the in 2010 regulated BDEs has therefore been in focus in this report.

Contact with stakeholders was crucial to analyse whether the exemptions have been applied in practice and to give a better understanding of its implications. Relevant European sector

associations and companies from the recycling sector were approached via e-mail to collect their input, see Annex II. In many cases this was followed up by telephone interviews. The identified sector associations were also asked to provide contact details to relevant recycling companies to include in the consultation. This strategy broadens the range of relevant companies to potentially contact and circumvent the difficult and time-consuming process of finding the right contact persons via standardised contact forms at companies' webpages. In order to present the status of recycled material for the different case studies, general internet searches were also conducted, as well as exploring sector associations' publications and webpages to gather relevant information. This report should not be regarded to cover all available information on the topic. The project was conducted under a limited budget and to some extent dependent on voluntary involvement of the contacted stakeholders. This report gives the perspective of the stakeholders which contributed in the consultation and could function as a starting point for further investigations.

3.1 Relevant literature and policy documents

The following literature was screened in order to find and evaluate any relevant literature and policy documents on exemptions implemented in the REACH Regulation.

Documents in the context of authorisation:

- List of substances included in Annex XIV of REACH ("Authorisation List") (ECHA 2020b)
- Adopted opinions and previous consultations on applications for authorisation incl. details (CSR, AoA, SEA & Compiled RAC and SEAC opinions)
- Applications for authorisation - current consultations (ECHA 2020a)

Documents in the context of restriction:

- Substances restricted under REACH (Annex XVII) including decision documents (ECHA 2020e)
- Previous calls for comments and evidence for the relevant substances (cadmium and DEHP) (ECHA 2020c)
- Registry of restriction intentions until outcome in order to check if any restriction relevant to recycling is planned (ECHA 2020d)

For the POPs Regulation, the following literature contains important background information for implementation of waste and recycling related provisions.

- Regulation (EU) 2019/1021 of the European Parliament and of the Council of 20 June 2019 on persistent organic pollutants (recast) (EC 2019d).
- Regulation (EC) No 850/2004 of the European Parliament and of the Council of 29 April 2004 on persistent organic pollutants (EC 2004).
- BiPRO (2015) *Study to facilitate the implementation of certain waste related provisions of the Regulation on Persistent Organic Pollutants (POPs) (BiPRO 2015).*
- ESWI (2011) Study on waste related issues of newly listed POPs and candidate POPs (ESWI 2011)
- Ramboll (2019) Study to support the review of waste related issues in annexes IV and V of Regulation (EC) 850/2004 (Ramboll 2019).

The following sources are relevant regarding the exemption for recovered spare parts under the RoHS Directive:

- Directive (EU) 2017/2102 of the European Parliament and the Council of 15 November 2017 amending Directive 2011/65/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment (EC 2017b).
- European Commission, *Staff working document: impact assessment accompanying the proposal for a Directive of the European Parliament and the Council amending Directive 2011/65/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment*, SWD(2017) 23 final, Brussels, 26.1.2017 (EC 2017c).
- Eunomia and Oeko-Institut (2014), *Additional Input to the Commission Impact Assessment for a Review of the Scope Provisions of the RoHS Directive Pursuant to Article 24(1)*, Publications Office of the EU (Eunomia_Öko-Institut 2014).

The following sources are relevant regarding the exemption based on Annex III and IV under the RoHS Directive:

- Eunomia , Fraunhofer Institute for Reliability and Microintegration (IZM) and Oeko-Institut (2016), *Assistance to the Commission on technological socio-economic and cost-benefit assessment related to exemptions from the substance restrictions in electrical and electronic equipment*, Publications Office of the EU (Eunomia 2016)
- BIPRO (2017), Study to assess 2 RoHS new exemption requests #1 for cadmium in video cameras designed for use in environments exposed to ionising radiation, #2 for lead and cadmium in PVC profiles of electric windows and doors : final report – Study, Publications Office of the EU (BiPRO 2017)Categorising motives and arguments for exemptions

In the beginning of the project, a number of potentially relevant categories for identifying the motives and arguments used to adopt the exemptions were defined. An overview of the identified categories is given in table 1 below.

Table 1. Overview of the potentially relevant categories for identifying the motives and arguments used to adopt the recycling exemptions under REACH, POPs and RoHS legislations.

Category	Explanation
Environmental	This motive or argument is based on environmental considerations and may entail the reasoning that specific environmental benefits of recycling of material containing hazardous substances brings environmental benefits which outweigh risks for the environment and human health.
Human Health	This motive or argument is based on considerations concerning the extent of the risk for human health posed by the recycling of material containing hazardous substances. This may for example entail argumentation regarding the level of exposure of the human beings to the hazardous substance in the recycled material.
Political	This motive or argument is based on considerations related to previously made political choices which support the adoption of an exemption. An example could be the EU´s ambitions to stimulate increased recycling under its circular economy action plan.
Economic	This motive or argument is based on economic considerations. An example would be that the adoption of an exemption would enable an industrial sector to continue or increase its activities which are based on the recycling operation or its output.
Technical	This motive or argument is based on technical considerations regarding the restriction of a hazardous substance. An example would be the difficulty of detecting a hazardous substance in a recyclable waste streams under a specific limit value.

Establishing clearly defined categories was useful to identify and describe the relevant motives and arguments in a structured, transparent and concise way. It should be noted that multiple of the categories presented above may be applicable to an identified argument or motive. For example, argumentation on the basis of resource efficiency can both be of an environmental and a political nature.

4 Recycling exemptions in the REACH Regulation

At first glance, recycling does not seem to be affected by REACH: Waste is not covered by REACH and substances recovered from waste are exempted from registration under certain conditions. Nevertheless, there are extensive obligations in other legislations covering the area of recycling, for example part of the Waste Framework Directive (WFD), the POPs Regulation and RoHS- Directive.

The distinction between waste and the individual substance, which falls under REACH, is not always well defined. ECHA gives advice on this topic in form of a guidance document on waste and recovered substances (ECHA 2010): In chapter 2.2.1, p. 5 of this guidance document it is stated

> "If waste ceases to be waste, a new life-cycle of the substances starts. The recovery process focuses on recovery of the substance from that waste. Therefore, in any event and by definition, recovery cannot be a use[5]" Furthermore, "For the sake of consistency and enforceability of the approach, all forms of recovery, including mechanical processing, are considered as a manufacturing process whenever, after having undergone one or several recovery steps, they result in the generation of one or several substances as such or in a mixture or in an article that have ceased to be waste."

4.1 Description of the exemptions implemented in the REACH Regulation

In this chapter, both instruments of REACH are considered: authorisation and restriction. In Table 2 and 3, an overview of exemptions made for recycling in authorisation and restriction dossiers and their application is given. Two substances, Bis(2-ethylhexyl) phthalate (DEHP) and 1,2-Dichloroethane (EDC), are currently covered by exemptions related to recycling under the authorisation procedure of REACH, see Table 2. For EDC there are two applicants. Up to 2019, there were three applicants for DEHP, of which only one fulfilled the reapplication process. Table 3 shows the status overview of restrictions that are relevant in the context of recycling. Two metals (arsenic and cadmium and their respective compounds) are restricted under REACH and for both these metals, a specific reference to recycling (reuse etc.) is included in their conditions.

[5] Article 3(24) defines "use" as "any processing, formulation, consumption, storage, keeping, treatment, filling into containers, transfer from one container to another, mixing, production of an article or any other utilisation".

Table 2. Status overview of adopted opinions and previous consultations on applications for authorisation. Only those with relevance for recycling shown.

ECHA Identifier	Name CAS number	Applicant	Date of Decision/ Date of expiry Year (month)	Status	Authorisation number	Remarks
0109-01	1,2-Dichloroethane (EDC) 107-06-2	Akzo Nobel Chemicals SpA	2019 (01)/ 2026 (11)	Granted	REACH/19/13/0	The use of 1,2-dichloroethane as recyclable solvent in the production of a polyacrylate surfactant
0060-01	1,2-Dichloroethane (EDC)[6] 107-06-2	BASF SE	2017 (06)/ 2024 (11)	Granted	REACH/17/9/0	Industrial use as a recyclable solvent and extraction agent in a closed system for purification of 1,3,5-trioxane
0122-01 0122-02	Bis(2-ethylhexyl) phthalate (DEHP) 117-81-7	Vinyloop Ferrara SpA	NA	Withdrawn	NA	Formulation of recycled soft PVC containing DEHP in compounds and dry-blends
0123-01 0123-02	Bis(2-ethylhexyl) phthalate (DEHP) 117-81-7	Plastic Planet srl.	NA	Opinions adopted	NA	Formulation of recycled soft PVC containing DEHP in compounds and dry-blends
0008-01 0008-02	Bis(2-ethylhexyl) phthalate (DEHP)[7] 117-81-7	Vinyloop Ferrara SpA.; Stena Recycling AB; Plastic Planet srl	2016 (06)/ 2019 (02)	Granted (expired)	REACH/16/2/0-5	Formulation of recycled soft PVC containing DEHP in compounds and dry-blends

[6] https://echa.europa.eu/de/applications-for-authorisation-previous-consultations?diss=true&search_criteria_ecnumber=203-458-1&search_criteria_casnumber=107-06-2&search_criteria_name=1%2C2-dichloroethane

[7] https://echa.europa.eu/de/applications-for-authorisation-previous-consultations?diss=true&search_criteria_ecnumber=204-211-0&search_criteria_casnumber=117-81-7&search_criteria_name=Bis%282-ethylhexyl%29+phthalate

Table 3. Status overview of restrictions that are relevant in the context of recycling.

Entry of Annex XVII	Name	CAS number	Date of Decision Year (month)	Remarks (Conditions of restriction)
23	Cadmium and it compounds[8]	7440-43-9 and its compounds	2016 (02)	... mixtures produced from PVC waste, hereinafter referred to as 'recovered PVC', mixtures and articles containing **recovered** PVC if their concentration of cadmium (expressed as Cd metal) does not exceed 0,1 % by weight of the plastic material in the following rigid PVC applications: (a) profiles and rigid sheets for building applications; (b) doors, windows, shutters, walls, blinds, fences, and roof gutters; (c) decks and terraces; (d) cable ducts; (e) pipes for non-drinking water if the recovered PVC is used in the middle layer of a multilayer pipe and is entirely covered with a layer of newly produced PVC in compliance with paragraph 1 above
19	Arsenic compounds[9]	7440-38-2 and its compounds	2009 (06)	... Wood treated with CCA (copper, chromium, arsenic) type C that was in use in the Community before 30 September 2007, or that was placed on the market in accordance with paragraph 4: — may be used or **reused** subject to the conditions pertaining to its use listed under points 4(b), (c) and (d), — may be placed on the market subject to the conditions pertaining to its use listed under points 4(b), (c) and (d).

[8] https://echa.europa.eu/documents/10162/3bfef8a3-8c97-4d85-ae0b-ac6827de49a9
[9] https://echa.europa.eu/documents/10162/a798c758-371f-41e5-a38d-5f8dc9ba739d

4.2 Arguments used for implementation of exemptions in the REACH Regulation

In this sub-chapter the relevant documents for the substances selected as case studies, DEHP, cadmium and EDC, are scrutinized more in detail. These substances are targeted by the REACH Regulation in different ways as shown in Tables 2 and 3 above. Arsenic and its compounds are not considered in this section, as the exemption applies to re-use of treated wood already placed on the market.

4.2.1 DEHP

DEHP is a substance that was used as a plasticizer, mainly in soft-PVC. It is considered to be a SVHC based on its toxicity to reproduction and endocrine disrupting properties. DEHP is covered by authorisation and restriction. In the following chapters, the respective arguments for both procedures are highlighted. The arguments are based on pre-defined checklists to help determine the main impacts of the "non-use" scenario compared against the "applied use" scenario as highlighted in the guidance document on SEA (socio-economic analysis) in authorisation (ECHA 2011).

4.2.1.1 Authorisation

In 2013 three individual companies; Vinyloop Ferrara SpA, Stena Recycling AB and Plastic Planet applied for authorisation of DEHP together in a consortium. Based on the information given in the SEA, the three applicants chose the "adequate control" route for authorisation which means that the risks to humans is adequately controlled.

The permission was granted to use DEHP in:

- Formulation of recycled PVC; and
- Production of PVC articles using recycled PVC [10].

The used arguments were (as highlighted in the SEA):

- Socio- and Economic impacts: *"a refused authorisation would lead to damage costs between 210-275 million Euro and a loss of 150-200 jobs."*
- Health risks: "[…] risks are adequately controlled."
- Technical (alternatives): *"no alternatives that are both technically and economically feasible"*.

The argumentation of the RAC/SEAC committee on the proportionality of continued use (i.e. do the benefits of continued use exceed the costs to society) rejected the opinion of the applicants that the risks to human is adequately controlled, as the remaining risks to workers health cannot be quantified based on the given information. Thus, in the opinion document, the facts and argumentation that lead to the granting of the applications are based on qualitative rather than quantitative considerations:

[10] The later use excludes the use in toys and childcare articles; erasers; adult toys (sex toys and other articles for adults with intensive contact with mucous membranes); household articles smaller than 10 cm that children can suck or chew on; consumer textiles/clothing intended to be worn against the bare skin; cosmetics and food contact materials regulated under sector-specific legislation.

- Economic impacts: *"There are significant economic costs, compared to the assumed turnovers, in case of non-authorisation for the applicants and their downstream users."*
- Socio- and Economic impacts: *"It is probable that there will be a loss of up to 200 jobs in case of non-authorisation."*
- Environmental risk: *"There are external costs for society associated with environmental and human health damage due to increased landfilling or incineration of flexible PVC wastes, increased production of virgin flexible PVC and reduced recycling rates."*
- Technical (alternatives): *"Alternatives are not likely to become available, in at least the coming decade; therefore, the socio-economic costs are not likely to change significantly in the foreseen future."*
- Promotion of recycling: *"There is a political and societal incentive to promote recycling as a sustainable way to handle natural resources."*

The European Commission, with its regulatory committee, followed these argumentation points and authorised the application, stating that

> "The socioeconomic benefits outweigh the risk to human health arising from the use of the substance and there are no suitable alternative substances or technologies in terms of their technical and economic feasibility for the applicants and some of their downstream users."

Already in 2017, Vinyloop Ferrara SpA and Plastic Planet re-applied for authorisation, but this time individually. The third company Stena Recycling AB did not reapply

Vinyloop Ferrara SpA announced in June 2018 the closure of its business because the company was bankrupt. Thus, the application was withdrawn. Even though the authorisation application was withdrawn, the application argumentation was screened within the context of this report in order to have a complete analysis. As a general remark, it can be said that the documents (SEA, AoA etc.) consider the same set of arguments as the initial application (ID 0008-01/02). However, this time the application is company specific, as the application process was not part of a consortium.

For the remaining company, PlasticsPlanet, the application currently has the status of "opinions adopted". This means that the opinions of ECHA´s risk assessment committee (RAC) and socio-economic analysis committee (SEAC) has been sent to the European Commission (as of November 2019). The Commission is bound to prepare a draft authorisation decision within three months of receipt of the opinions from the agency and they might adopt the final decision granting or refusing the authorisation. This time frame has been overstepped at the time of finalising this report and no decision has been published (as of March 2020). The application documents for a renewal of the authorisation again highlights mostly socioeconomic considerations with an emphasis on the advantages of a continuation of recycling.

- Environmental impacts: *"Waste collectors will continue to be able to supply post-consumer flexible PVC wastes to the Authorisation holder, rather than having to incur gate fees for landfill or incur the costs of export outside the EU"*
- Economic impacts: *"Although Plastic Planet earns revenue from the sales of recyclate, the recycling of post-consumer soft PVC waste is undertaken in part because it is a lower net cost alternative to transporting and disposing of the waste via landfill or incineration."*

- Economic impacts*: "The Authorisation holder will be able to continue the recycling of post-consumer and post-industrial flexible PVC, adding to EU GVA through this activity and the avoidance of downstream users having to shift to more expensive raw materials"* whereby *"economic benefits of renewal of the authorisation over the period from 2019 to 2025 are estimated in the range €30 to €50 million"*
- Social impacts: *"Employees of the Authorisation holder will retain their jobs, with this also giving rise to consequent multiplier effects of jobs within the local community and relevant service sectors"* also *"Employees of the downstream converters will also retain their jobs, and thereby avoid the social costs of unemployment."*
- Wider environmental/health impacts: *"avoid the export of wastes and the potential for articles based on the recyclate to be imported back into the EU, or for exposures to occur to DEHP in other countries where controls on exposure are less stringent than in the EU"*

In the consolidated version of the RAC and SEAC opinions, the following facts and argumentations are shown. Worth noting is that the first argument is already sufficient to grant an authorisation:

- Human health & environmental risks: *"Conformation of an adequate control of risks from the use applied for"* and *"adequate control has been demonstrated for workers and humans exposed via the environment."*
- Economical: *"[..] assessment of costs and benefits, although accompanied by uncertainties and showing room for improvement, is appropriate to conclude that the benefits of continued use outweigh the risks to human health. The latter are expected to be zero."*
- Technical (alternatives): *"no suitable alternatives in terms of their technical and economic feasibility for the authorisation holder"*

Table 4 shows an overview on the arguments for the DEHP- recycling exemption as highlighted in the respective decisions documents that grant an authorisation.

Table 4. Overview on the arguments in favour of the DEHP-recycling exemption (authorisation) under the REACH Regulation

ID	Title	Category of argument	Description of argument in authorisation decision	Counter-argument[1]
0008-01 & 0008-02	Formulation of recycled soft PVC containing DEHP in compounds and dry-blends & Industrial use of recycled soft PVC containing DEHP in polymer processing by calendering, extrusion, compression and injection moulding to produce PVC articles	Political (Promotion of recycling) Economic (Loss of turnover) Environmental (Due to landfilling and incineration) Economic (Loss of employment) Technical (No alternative) [11]	*"The socioeconomic benefits outweigh the risk to human health arising from the use of the substance and there are no suitable alternative substances or technologies in terms of their technical and economic feasibility for the applicants and some of their downstream users."* [12]	Human health

[11] Article 60(4) of Regulation (EC) No 1907/2006 and Joint Analysis of Alternatives and Socio-Economic Analysis (non confidential report)
[12] http://ec.europa.eu/DocsRoom/documents/17442

0122-01 & 0122-02	**WITHDRAWN**	Economic (Continuation of recycling & employment) Technical (No alternative[13])	Not applicable	Not applicable
0123-01 & 0123-02	Formulation of recycled soft PVC containing DEHP in compounds and dry-blends & Industrial use of recycled soft PVC containing DEHP in polymer processing by calendering, extrusion, compression and injection moulding to produce PVC articles	Human health & environmental (Adequate control proven) Economical (Benefits outweigh the risks to human health) Technical (No alternative)[14]	Not yet decided	Not applicable

[1]As used in the evaluated documents. Only if it is clearly indicated, the category of the argument has been possible to identify.

4.2.1.2 Restriction

In 2015, Denmark and ECHA published their intention for a restriction under Article 69(2) on the four classified phthalates in articles. Next to DEHP, this restriction also includes three more phthalates (Benzyl butyl phthalate (BBP) Dibutyl phthalate (DBP) and Diisobutyl phthalate (DIBP)). The opinion document of SEAC and RAC on this restriction addresses no specific exemption for recycling (Vinyloop 2017). However, the authors calculated the costs for the recycling sector and highlighted that the majority of articles manufactured from recycled PVC are for industrial or agricultural use for which the proposed restriction foresees a derogation.

The main articles impacted from the restriction would be wellingtons and other boots. SEAC anticipated that the manufacturers would be able to comply with the restriction. Therefore, the costs to recyclers to comply with the restriction would range from transaction costs to the costs to transition to virgin plastisol, dry-blends or compound as the highest cost possible strategy and are estimated at €1.1 million annually, assuming a mix of these strategies. The producers of wellingtons and other boot would likely bear the majority of these costs. Given the small volume of soft PVC waste affected, it is assumed that industry would identify a market for all DEHP-containing waste currently being recycled. It is expected that the amount of waste will not increase as a result of the proposed restriction.

Based on the announcement of intention, various stakeholders were invited to address their potential need for exemption for certain articles containing DEHP, DBP, DIBP and BBP in excess of 0,1% w/w, individually or in combination. In the restriction itself, recycling is not considered. However, in this sub-task of the project, comments of stakeholders on the SEAC draft opinion were screened to see whether they are relevant in terms of recycling. There was

[13] Socio-Economic Analysis (non confidential report) (Vinyloop 2017)
[14] Socio-Economic Analysis (non confidential report)

no specific argument raised concerning recycling (ECHA 2018). In December 2018 the restriction came into force as Entry 51 of Annex XVII.

4.2.2 Cadmium

Cadmium is a toxic heavy metal, identified as a SVHC based on its carcinogenic properties. Cadmium and its usage in plastics has been a target of EU´s regulatory action for a long time. For example, already in 1988, a resolution for an action program to combat environmental pollution by cadmium was adopted. The resolution was mainly based on the usage of cadmium as a colouring agent or stabilizer in some plastic articles. In addition, cadmium has been prohibited in the EU in a number of plastic articles since 1992 but was still allowed in some rigid PVC since no alternatives were available at the time. As of 1 June 2009, the Marketing and Use Directive (76/769/EEC) was replaced by REACH Annex XVII which lists various restrictions on cadmium and its compounds. This restriction foresees a derogation for cadmium in recovered PVC. As the Commission intended to propose amendments to Annex XVII relating to further restrictions on the uses of cadmium, a study was performed covering the socio-economic impact of a potential update of the restrictions on the marketing and use of cadmium (RPA 2014). That study was further accompanied by a working document prepared for the staff of the commission (EC 2017b). In the reports three policy options are discussed:

- Business as usual
- Complete restriction of cadmium in PVC
- restriction with a time limited higher cadmium concentration level for certain building articles if manufactured with PVC recyclate.

The following arguments (pro/contra) for the third policy option, supporting recycling, are presented:

- Environmental impacts: *"Alternative treatment methods for PVC waste are incineration and in landfilling. In some MS landfilling of untreated waste, including PVC is prohibited, while in others landfilling of untreated PVC is still allowed. Both methods imply a risk of release of the cadmium contained in the PVC to the environment through leakage and fumes. However, the biggest impact on the environment is the release of CO_2 during incineration."*
- Recycling of a long-term perspective/sustainability: *"The cadmium concentrations in PVC waste and consequently in non-pressure pipes and round cable ducts made from recycled PVC will not remain static and are expected to rise for a number of years but will subsequently decline and eventually fall below 100 ppm (beyond 2040-2050). Therefore, it would be prudent to increase the cadmium content limit for building products and for a limited period only, after which an evaluation could be undertaken to establish more conclusively the presence of cadmium in waste and in finished articles."*
- Economic impact: *"There is no evidence that SMEs (Small and Medium Enterprise/Small and Mid-sized Enterprise) would be disadvantaged under the preferred policy option. Therefore, we do not believe that any mitigation measures aimed at SMEs are needed. Many companies in the recycling sector are SMEs and these will to a large extend benefit from the implementation of the preferred option."*

In a related press statement of 2011, a European Commissioner stated that: *"The ban on cadmium in jewellery will protect consumers, in particular children. It is equally good for the environment, as cadmium-free plastics will help to reduce pollution. The measure encourages*

the recycling of PVC waste, which represents significant progress in the efforts to save resources." (EC 2011a)

Table 5 gives an overview of the arguments used for the restriction of cadmium use under the REACH Regulation.

Table 5. Overview on the argument for the cadmium recycling exemption (restriction) under the REACH Regulation

	Category of argument	Description of argument	Counter-argument
Cadmium	Environmental (no landfilling or incineration) Economic (no impact on SME)	*"Recycling appears to be the most environmentally friendly and possibly also the least costly waste management option in relation to PVC profile waste"*[15]	None identified

Similarly to the cadmium exemption, also lead (Pb) will be targeted in the future as ECHA is currently working on a restriction for PVC containing lead compounds. ECHA's initial proposal considered a threshold of 0,1% lead content for articles not containing recycled PVC. For some rigid building and construction articles produced from recycled PVC, a 15-year derogation was planned to allow a higher lead content. The EU parliament voted against this proposal in February 2020. The objection of the Parliament means that the Commission cannot adopt the draft measure and will now either submit a new or amended version.

4.2.3 EDC

1,2-Dichloroethane (EDC) is considered to be a SVHC based on its carcinogenic properties and it is listed in Annex XIV of REACH, requiring authorisation to use. Currently, there are two authorisations granted with relevance to recycling. BASF SE (DE) is authorized to used EDC in "Industrial use as a recyclable solvent and extraction agent in a closed system for purification of 1,3,5-trioxane" and Akzo Nobel Chemicals SpA (IT) uses EDC for "The use of 1,2-dichloroethane as recyclable solvent in the production of a polyacrylate surfactant" (EC 2017a, 2019a). In the following, the applications will be considered independently, as they highlight partly different argumentation.

BASF presents a variety of arguments for usage of EDC, that are based on technical, economic, environmental, and health-related considerations. The respective arguments are shown in Table 6. Akzo Nobel Chemicals SpA also bring forth social and economic arguments, which are also presented in Table 6.

[15] https://ec.europa.eu/commission/presscorner/detail/en/IP_11_620

Table 6. Overview on the arguments for the EDC-recycling exemption (authorisation) under the REACH Regulation

Applicant	Category of argument	Description of argument in authorisation decision	Counter-argument[1]
BASF	Technical	No alternatives, although extensive research was undertaken (>7000 substances screened)	None identified
BASF	Economic	Reduced Tax & other revenues for EU	
BASF	Economic	Higher costs for end-user due to change of product	
BASF	Economic	Loss of market share	
BASF	Environmental	No concern for humans exposed via environment	
BASF	Human health	Remaining cancer risk is very small	
BASF	Economic	Loss of employment	
Akzo Nobel Chemicals SpA	Technical	No alternatives	
Akzo Nobel Chemicals SpA	Economic	Reductions in output and employment in supply chains & local communities	
Akzo Nobel Chemicals SpA	Economic	Relocation to Mexico	
Akzo Nobel Chemicals SpA	Economic	Loss of employment	

[1]As used in the evaluated documents. Only if it is clearly indicated, the category of the argument has been possible to identify

4.3 Assessment of the use and effects of the DEHP and cadmium exemptions in the REACH Regulation

DEHP and cadmium were selected to be used as case studies to evaluate the use and effects of the recycling exemptions under REACH Regulation. DEHP is regulated by an authorisation procedure and cadmium by a restriction. EDC was not further studied.

4.3.1 DEHP

4.3.1.1 Use of DEHP and relevant waste fractions

DEHP is a plasticiser, mainly used in the manufacturing process of soft PVC. The three major fields of application are the health care sector (e.g. tubes, oxygen masks, blood bags), the building sector (flooring and roofing) as well as insulations for cables and wires.

Initially, three individual companies applied for an authorisation for the recycling of DEHP-containing PVC. Thus, the exemption on “formulation of recycled soft PVC containing DEHP

in compounds and dry-blends" under REACH was limited in the past to three involved companies. Although these three companies did apply as a consortium, each of them formulated the recycled soft PVC containing DEHP in individual processes which could also include different waste fractions. As of today, only one of these companies have a granted authorisation, as the other company which re-applied did withdraw its application and ceased business.

Plastic Planet highlights in the SEA that in 2016, 568,696 tonnes of PVC were recycled in the context of the VinylPlus consortium (PlasticPlanet 2017). VinylPlus is a consortium of companies based on a renewed 10-year voluntary commitment to sustainable develop the European PVC industry. The sources of this waste include:

- Coated fabrics (8,187 tonnes);
- Post-consumer flooring (3,811 tonnes);
- Flexible PVC including roofing materials (91,811 tonnes); and
- Cables (127,214 tonnes),

Around 7% of this waste (39,760 tonnes) was exported to countries outside the EU.

As indicated in the SEA, Plastic Planet and Vinyloop Ferrara SpA account only for a small fraction of the total flexible PVC waste that was recycled in 2016 (PlasticPlanet 2017). The major part of the flexible PVC waste recycled, was handled by integrated recyclers which convert flexible PVC waste directly into articles at the same facility. These companies are exempt from authorisation as the recycling and converting processes are integrated at their facilities. It has been confirmed by the European Commission that integrated recyclers fall under waste legislation and therefore fall outside REACH requirements. However, the companies still have to comply with REACH (for example restrictions in Annex XVII and the information provisions in article 33), since they are manufacturers of articles.

Plastic Planet states, that this status places the integrated recyclers in a competitive advantage compared to them as they do not have to apply for authorisation (PlasticPlanet 2017).

More recent data shows, that in 2018, around 735,000 tonnes of recycled PVC waste was registered, a 16 % increase from 2017 (Recovinyl 2019). However, it is unknown how much of this waste was recycled by any of the application holders or the integrated recyclers. This is also due to the fact that any information on this is confidential business information, and therefore it is concealed in the SEA of Plastic Planet. For Vinyloop, the produced volume in 2016 was 3,800 tonnes of recycled PVC. That would account for approximately 4 % of the total flexible PVC recycled in the VinylPlus framework that year (around 92,000 tonnes).

4.3.1.2 Assessment of the utilization of recycling exemption

With the aim to gather information on the effects of the exemption, the three (former and recent) applicants Vinyloop Ferrara SpA, Stena Recycling AB and Plastic Planet were contacted in this project. In addition to that, also several relevant sector associations have been contacted.

The only company where contact was established was Stena Recycling AB. The other two companies did not respond to email and/or telephone calls. However, for Vinyloop Ferrara SpA, an interview with a representative published on the internet was found, which answers many of the project relevant questions (Estense 2018).

The following information is taken from this interview (available only in Italian) (Estense 2018). Vinyloop Ferrara SpA was a company in northern Italy that was recycling PVC from

cables and tarpaulins. The company did not reapply for authorisation for several reasons but the main reason being economical:

- Profit loss: 12 % between the years 2015-2016. Produced volume in 2016 was 3,800 tonnes of recycled PVC.
- Low demand: customers preferred buying virgin PVC without issues with legacy substances like DEHP.
- No economic incentives for using recycled PVC instead of sending it to landfills, incineration or exporting it outside the EU.
- Unfair competition: companies outside the EU are expected to have an advantage since the import of DEHP containing PVC articles could go on while the European industry had to apply for authorisation.
- High costs in time and money for authorisation: authorisation process was seen as both costly, time consuming and due to the limited time frame for granted applications, it introduced an uncertainty affecting investments.
- High costs for further research and development: Large scale industrial methods to separate DEHP from PVC were also not available and would have cost too much to implement taking into account the weak demand and lack of incentives for the customers as described earlier. In addition, the granted period of 7 years was perceived as being too short for the intended business model.

Vinyloop Ferrara SpA closed its operation in June 2018 and the company was put in liquidation. Further information sources suggest, that it was not economically feasible to recycle DEHP-containing PVC with the Vinyloop Ferrara SpA process (Plasteurope 2018). The facility was later bought by Benvic, a French company that guaranteed a further employment for the seventeen Vinyloop Ferrara SpA workers. Benvic has now redeveloped the Ferrara site building a production line dedicated to the production of thermoplastic elastomers (TPE) and biopolymers (Plasticnews 2019).

Stena Recycling AB was granted an authorisation in the first round and then decided not to reapply. In the contact with the company, a representative from Stena Recycling AB was interviewed (StenaRecyclingAB 2020).

Stena Recycling AB had facilities in two locations in Sweden to recycle DEHP-containing PVC cables. Many newer cables used in construction are halogen-free, which uses aluminum hydroxide as a flame retardant. However, these cables become much stiffer and, in some applications, e.g. car doors, there is still a need for a soft plastic and then PVC is used. In the recycling plant the cables were crushed to pieces and the plastics were separated from the metals through various mechanisms. Historically the plastics were landfilled but Stena Recycling AB saw an opportunity to instead recycle and sell it to customers in other European countries. Examples of products made from the recycled PVC were cable protection products e.g. for roads and the base for road cones, plastic pallets and cable drums.

As the recycling of PVC was an ongoing business model at Stena Recycling AB, an application for the continued recycling became necessary when the authorisation of DEHP was introduced under REACH. In the interview, the representative from Stena Recycling AB highlighted economic reasons for not re-applying for authorisation:

- High costs in time and money for authorisation and no market: the authorisation process took several years and after everything was approved and running, the customers had switched to other raw materials and the market was gone.

- Unfair competition: The European regulatory framework allows unfair competition from import of plastics containing substances that are under authorization in Europe.

When Stena Recycling AB ceased recycling of DEHP containing PVC from cables, the material is once again sent to landfill, as it contains high levels of chlorine (StenaRecyclingAB 2020). According to Stena Recycling AB, no waste incinerating operator wants to handle high chlorine content materials which increases corrosion on their process equipment. The Stena Recycling AB representative states that the status today is that the DEHP-containing PVC material cannot be recycled, and nobody wants to use it for incineration.

Also, VinylPlus, a consortium of European PVC companies, take a stand on legacy additives (i.e. low molecular weight phthalate plasticisers, as well as lead and cadmium stabilisers). In its opinion, particularly lead and DEHP are considered to be a major threat to the recycling of post-consumer waste by all sector groups. In addition, VinylPlus, states that "*removing DEHP from the recycled product is not currently feasible on an industrial scale*" (VinylPlus 2019b).

Taken together, the following effects of the authorisation of DEHP in the context of PVC-recycling have been identified:

- High costs in time and money for the recyclers based on the authorisation procedure itself.
- Decreased demand for recycled DEHP-containing PVC, resulting in a higher demand of virgin materials or products by integrated recyclers.
- Increased amount of incinerated or landfilled DEHP-containing PVC.
- Perception of unfair competition in a global context (import of DEHP-containing PVC from e.g. China) compared to integrated recyclers.

4.3.2 Cadmium

This section will focus on the exemption for recovered PVC as laid down in paragraph 4 of the REACH restriction for cadmium. As such, focus of this section will be on recycling operations for the allowed applications under this exemption:

a) profiles and rigid sheets for building applications;
b) doors, windows, shutters, walls, blinds, fences, and roof gutters;
c) decks and terraces;
d) cable ducts; and
e) pipes for non-drinking water.[16]

More specifically, the section will focus on the recycling PVC in profiles and pipes, as these currently constitute the main recycled streams. As these two streams constitute rigid PVC waste, the section will pay specific attention to this type of PVC waste. The more so, as the applications allowed by the REACH restriction mainly require rigid PVC as input material.

It should be noted that the data on which this section has been based mainly originates (directly or indirectly) from the PVC recycling sector. The 2009 study on the cadmium content of recycled PVC waste which has been carried out by research organisation VITO for

[16] Additional requirement is that the recovered PVC is used in the middle layer of a multilayer pipe and is entirely covered with a layer of newly produced and compliant PVC.

Vinyl2010 (VITO 2009)[17] has been consulted quite intensively. Other referenced studies also seem to draw considerably on data provided by the PVC sector.

The REACH restriction on cadmium requires that the derogation granted in paragraph 4 is reviewed, in particular with a view to reducing the limit value for cadmium and to reassess the derogation for the applications listed in points (a) to (e), by 31 December 2017. It is our understanding that, on this basis, the European Commission has contracted VITO to re-assess its findings from 2009. As such, the considerations below may be seen in a new light upon the completion of this re-assessment.

4.3.2.1 Use of cadmium in PVC and relevant waste fractions

The most recent industry estimates on the volume of PVC waste generated in EU per year is 2.5 million tonnes (Fråne 2019; VinylPlus 2019a)[18]. This estimate is in line with an earlier calculated 2.6 million tonnes by the Dutch National Institute for Public Health and the Environment (RIVM)(RIVM 2016) . However, it is not clear what the total share is of rigid PVC waste in this amount.

The VITO report provides the following estimates of the development of PVC waste[19] generation until 2050. Table 7 below distinguishes between:

- estimates on generation of specified PVC waste streams as a whole; and
- estimates on generation of specified streams of cadmium containing PVC waste.[20]

Table 7. Estimation of PVC waste generation in tonnes until 2050. In the table the first column gives the separate figures for overall PVC waste and the second column presents the figures for cadmium containing PVC waste (Cd cont. PVC waste).

	2000		**2010**		**2020**		**2050**	
	Overall PVC waste	Cd cont. PVC waste	Overall PVC waste	Cd cont. PVC waste	Overall PVC waste	Cd cont. PVC waste	Overall PVC waste	Cd cont. PVC waste
Profiles[21]	63,036	47,584	167,322	117,234	355,546	142,143	927,963	25,273
Roofing membranes	3,570	3,421	7,392	4,608	12,057	3,110	Not determined	
Cables	65,994	50,154	131,831	100,249	211,497	121,906	Not determined	
Flooring	389,384	73,399	471,408	23,531	480,626	1,441	Not determined	
Pipes	40,580	0	84,424	0	140,046	0	Not determined	

The same report indicates (based on data provided by Recovinyl) that PVC profiles make up 67% of the composition of mixed rigid PVC waste. Pipes constitute the second biggest group

[17] Vinyl 2010 was the first voluntary commitment of the European PVC industry. It was succeeded by VinylPlus.
[18] VinylPlus estimates 2.9 Mton "available" PVC waste with 1 Mton available from building sector in 2020:
[19] The estimates concern post-consumer waste.
[20] This distinction is relevant, as Cadmium has not been used in all PVC applications.
[21] The VITO report groups profiles for windows and profiles for other building applications under this category.

in the composition with 27% (VITO 2009). Based on the estimates presented in Table 7, the share of rigid PVC waste (post-consumer) in the general amount generated would currently be at least 495,592 tonnes (based on profiles and pipes waste volumes in 2020). The amount of rigid PVC waste containing cadmium would currently be at least 142,143 tonnes.

It is relevant to note that the VITO report indicates that by 2020 the amount of cadmium containing waste from PVC profiles will still be rising. However, the projection in the connected graph in the report also seems to show a starting decline in generated cadmium containing waste from PVC profiles after 2020. This is relevant, as waste from PVC profiles seems to be the largest rigid PVC waste stream which may contain cadmium.

Cadmium concentrations in PVC waste

As mentioned above, waste from PVC profiles currently constitutes the biggest stream of rigid PVC waste which contains cadmium. The second biggest stream, being pipes, does not contain cadmium, as this substance was not used as a stabiliser in pipes (VITO 2009).

The VITO report, published in 2009, projects that the average cadmium concentration in PVC profiles waste (with and without recycling) will have dropped below 1000 ppm by 2017(VITO 2009). The report projects that the average cadmium concentration in this waste stream will reach 100 ppm in 2045. Furthermore, it is estimated that the average cadmium concentration between 2010 and 2020 will vary between 1400 and 800 ppm. Finally, it is relevant to note that the projections indicate that non-recycling of cadmium containing PVC profiles waste will cause a more rapid drop in average cadmium concentration from 2030 onwards. In fact, it is under this scenario that the projected average concentration under 100 ppm will be reached by approximately 2045.

Partly based on the data for waste from PVC profiles, the VITO report estimates an average cadmium concentration of 960 ppm in mixed rigid PVC waste.[22]This is a relevant estimate, as such mix may constitute the input for recycling operations for PVC pipes. The report projects that the average cadmium concentration in mixed rigid PVC waste will have dropped below 800 ppm by approximately 2014 and under 600 ppm by 2019. Furthermore, the report projects that average cadmium concentration in mixed rigid PVC waste will drop below 100 ppm in 2041.

It should be noted however, that the European PVC Window Profile and related Building Products Association (EPPA) expects a rise in cadmium concentrations in PVC profiles waste in the future. EPPA indicated that, based on industry calculations, the peak is expected in 10 to 15 years from now (EPPA 2020). EPPA further explained that the peak will be reached when the maximum amount of old, cadmium containing window profiles dismantled per year is reached. Afterwards, the amount of old window profiles containing cadmium will be diluted with the amount of old windows no longer containing cadmium, thereby decreasing the overall cadmium levels.

The European Plastic Pipe and Fittings Association (TEPPFA) does not expect a rise in cadmium concentration in the PVC waste stream in the future (TEPPFA 2020). This is due to the fact that the recycled content used for the middle layer of multilayer pipes will increasingly be composed of recyclate originating from a mixture of pre-consumer PVC and post-consumer PVC which does not contain cadmium as a stabiliser (as cadmium was replace

[22] It should be noted that this estimate was made in 2009

by e.g. lead).[23] TEPPFA furthermore indicates that the concentration of cadmium in rigid PVC waste streams is substantially low. This low concentration was confirmed by the measurements of Cadmium concentrations in PVC pipe with a recycled middle layer carried out by VITO at request of TEPPFA in 2017 (TEPPFA 2020). A similar indication is also provided by PVC pipes recycling company "van Werven" which tests its recycled PVC twice a year and finds that the cadmium concentration in recycled PVC is "far below the limit" (NC 2019).

PVC recycling

The total volume of recycled PVC within the VinylPlus initiative in 2018 was 739,525 tonnes. As such, rigid PVC recycling constituted at least 55% of these recycling activities with a tonnage of 408,911 (VinylPlus 2019b).

The main recycled streams of rigid PVC waste originate from window profiles and related profiles; and pipes and fittings. Figure 2 provides an overview of the development in recycling volumes in EU for these two streams since 2004 (Vinylplus 2004-2019). The tonnage for windows profiles and related profiles depictured in the graph below, also includes the volumes for Switzerland from 2014. From 2015, the tonnage for pipes and fittings includes the volumes for Switzerland.

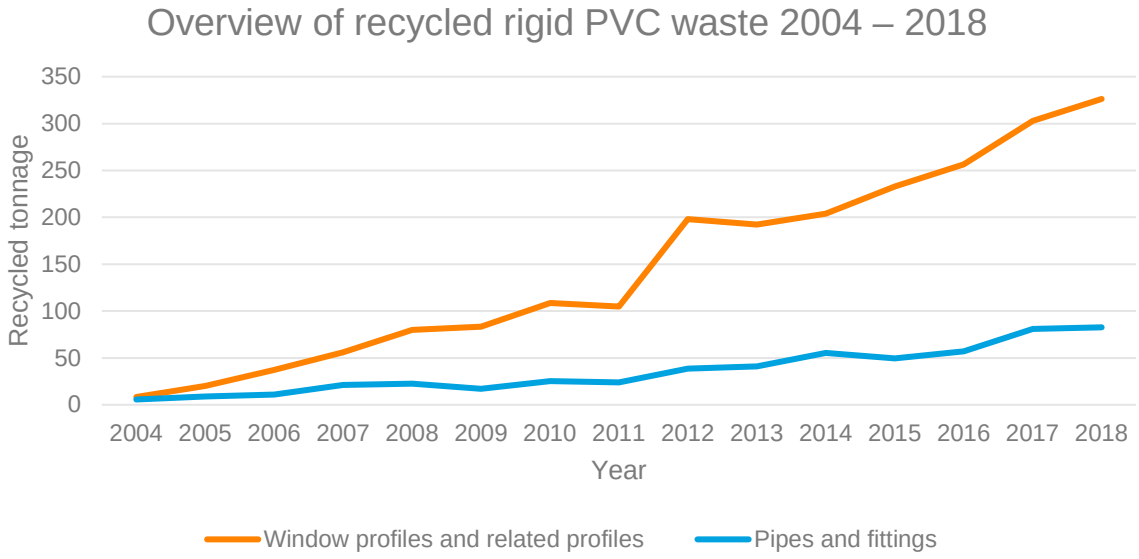

Figure 2. Overview of the increased amount of recycled rigid PVC waste in EU between 2004 and 2018. From 2014 the volumes in Switzerland is included for windows and related profiles and from 2015 the tonnages for pipes and fittings covers the Swiss volumes as well.

The main recycling process for PVC waste currently is mechanical recycling (NC 2019). Mechanical recycling involves the grinding of PVC waste without changes to the chemical composition. The ground PVC is melted to pellets which are then used as input material for PVC production (Sadat-Shojai & Bakhshandeh 2011). Chemical recycling is perceived as a

[23] TEPPFA does indicate that there can be one off exceptions with a batch with a higher concentration depending on the age and the origin of the recycled windows. TEPPFA expects this to be rather the exception than the rule; Personal communication with TEPPFA (11.02.2020)

possible alternative recycling process. However, the application of this process seems to be limited currently (NC 2019).

In the profiles sector, recycled rigid PVC waste is used as input material in combination with virgin PVC. This enables the producers to ensure that the cadmium concentration in produced profiles stays below the 1000 ppm limit value. According to EPPA the process implies an ongoing dilution. The lowest cadmium concentrations are in the final products. The more post-consumer windows are collected, the higher the cadmium concentration will be in the final product. This will remain until a point in time (EPPA indicated 10-15 years from now) where the peak of cadmium concentrations is reached in recycled PVC. This information is also provided by PVC profiles recycler "VEKA", which stated that the feedstock for window profile manufacturing currently contains recycled PVC in a range of 5-10% to keep the Cadmium concentration below 1000 ppm (NC 2019). EPPA indicated that this range can be generalized for the entire sector and that 10% of European production is complemented with recycled material (EPPA 2020).

TEPPFA indicated that for the production of multilayer pipes there is no blending of recycled PVC with virgin PVC. The process is that of tri-extrusion. The outer and inner layer are made of virgin material, the core is made of recycled material (TEPPFA 2020).

4.3.2.2 Assessment of the utilization of recycling exemption

The data on the recycling of PVC pipes and profiles waste shows a steady increase in volumes. In addition, the recycling volumes seem to move fairly in line with PVC waste generation projections of the VITO report. The combined recycling tonnage in 2018 for profiles and pipes (408,911 tonnes) is close to the projected accumulated generation of PVC waste from profiles and pipes in 2020 (495,592 tonnes).

Another potentially relevant consideration is that the recycling tonnage for PVC waste profiles increased markedly (by 90%) between 2011 and 2012. This is the year in which the cadmium exemption was adopted under the relevant REACH restriction (EC 2011b). As mentioned above, this constitutes the main PVC waste streams which contains concentrations of cadmium. However, without a comprehensive assessment of other potential external factors, no definite correlation between these two developments can be assumed.

Recovinyl indicated that, if the derogation up to 1000 ppm would not have been granted, recycling of a large proportion of products would have stopped. Furthermore, the organisation indicates that the large increase in recycling of window and related profiles between 2011 and 2018 would not have been achievable without the derogation (Recovinyl 2020).

TEPPFA indicated that the cadmium exemption under REACH as such did not lead to an increase in the recycling of end-of-life PVC pipes. The exemption rather enabled the continued use of recycled material mainly coming from some postconsumer windows as a middle layer (co-extrusion) in PVC pipe production processes. According to TEPPFA, recycling volumes evolution are determined by the need for replacement of PVC pipes at end-of-life (lifetime estimated at 100 years) (TEPPFA 2020).

EPPA also indicated that the exemption enabled the continuation of recycling of PVC containing cadmium into profiles. EPPA mentioned that there was no restriction on the use of cadmium in profiles before the adoption of the restriction in 2011. Therefore, the exemption enabled the industry to continue business as usual. EPPA added that, nevertheless, recycling volumes are rising. This however is not considered by EPPA to be a consequence of the exemption but the general market conditions and renovation rates (EPPA 2020).

With regard to the extent to which recyclers currently rely on the limit value of 1000 ppm, the current levels of cadmium in rigid PVC waste become relevant. As indicated above, the VITO report projected that the average cadmium concentration in mixed rigid PVC waste will have dropped below 800 ppm by 2014 and approximately under 600 ppm by 2019. The average concentration in PVC profiles waste dropped below 1000 ppm in 2017 but concentration may vary between 1400 and 800 ppm until 2020, according to VITO projections.

The projections for mixed and profiles PVC waste seem to be supported by indications of the pipes recycling sector. However, it should also be noted that EPPA expects a future rise in cadmium concentrations in PVC profiles waste. EPPA indicated that the fact that the sector does not need 1000 ppm as a limit value now does not mean that it will not need it in the future. EPPA added that the levels of cadmium concentration also depend on production volumes. In the case of lower production volumes less post-industrial material will be available to dilute post-consumer PVC.

In this regard, it is relevant to note that the 1000 ppm limit value has a direct effect on the share of recycled PVC which can be blended with virgin PVC for the production of new PVC profiles. The higher the limit value, the bigger the possible share of recycled PVC (and vice versa). As such, in the case of blending, the height of the limit value does not seem to concern the absolute feasibility of recycling, but rather the volume in which it can take place.

The indications above raise the discussion as to what extent the current practice of the PVC recycling sector is still based or dependent on the limit value of 1000 ppm. However, it should be noted that the projections concerning the development of concentrations of cadmium in PVC waste were made by VITO in 2009. As such, it may be more accurate to re-visit the considerations of this section on the basis of the re-assessment of data which is currently being carried out by VITO.

5 Recycling exemptions in the former POPs Regulation

5.1 Description of the exemptions implemented in the former POPs Regulation

In the former POPs Regulation ((EC) No 850/2004) in scope of this report, there were specific derogations for tetra-, penta-, hexa- and heptabromodiphenylethers included in Annex I, Part A. The unintentional trace contaminant level of these in 2010 regulated brominated diphenylethers (BDEs) was 10 mg/kg, but the derogation specifically stated that the production, placing on the market and use of the following was allowed (identical wording for all four above mentioned BDEs):

"(a) without prejudice to subparagraph (b), articles and preparations containing concentrations below 0,1 % of hexabromobiphenyl ether by weight when produced partially or fully from recycled materials or materials from waste prepared for re-use;

(b) electrical and electronic equipment within the scope of Directive 2002/95/EC."

Table 8 below gives an overview of the recycling exemptions in the POPs Regulation. In the recast of the Regulation, this explicit recycling exemption does no longer exist. Instead, the Regulation allows an unintentional trace contamination amounting to 500 ppm in articles expressed as the sum of all 5 regulated brominated flame retardants (including decaBDE).

Table 8. Status overview of recycling exemptions in the former POPs Regulation EC No 850/2004 and in the RoHS Directive.

Substance	Unintentional trace contamination limit[1] (mg/kg)	Exemption for recycled material (mg/kg)	Exemption for use in EEE within the scope of 2002/95/EC (mg/kg)
Tetrabromodiphenyl ether $C_{12}H_6Br_4O$	10	1000	1000[2]
Pentabromodiphenyl ether $C_{12}H_5Br_5O$	10	1000	1000[2]
Hexabromodiphenyl ether $C_{12}H_4Br_6O$	10	1000	1000[2]
Heptabromodiphenyl ether $C_{12}H_3Br_7O$	10	1000	1000[2]

[1] Applicable for substances, articles, preparations and flame retarded parts of articles

[2] Sum PBDE including decaBDE

5.2 Arguments used for exemptions in the former POPs Regulation

As described previously, the derogation for recycled material containing tetra-, penta-, hexa- and heptabromodiphenylethers) was a part of former POPs Regulation ((EC) 850/2004) and the exemption was later repealed when the recast of the Regulation (EC) 1021/2019) came into force in June 2019. The inclusion of the recycling exemption took place through the amendments (EU) No 756/2010 and (EU) No 757/2010, both adopted on August 24th, 2010. The recycling exemptions for the in 2010 regulated BDEs were therefore valid for almost 9 years. To find the reasons and arguments for the implementation of this exemption, it is necessary to go to the Stockholm Convention in which the exemptions were first included.

5.2.1 The exemptions in the Stockholm Convention

The background to adopting specific recycling exemptions for the in 2009 listed BDEs can be found in documents from the meetings of the Conference of the Parties to the Stockholm Convention on Persistent Organic Pollutants, hereinafter COP. As an integrated part of the procedure to list substances under the Stockholm Convention, the Persistent Organic Pollutants Review Committee (POPRC), a subsidiary body to the Stockholm Convention, reviews chemicals proposed for listing. A detailed description of the procedure can be found in a handbook published by UNEP (UNEP, 2009).

In the risk management evaluation on commercial pentabromodiphenyl ether (C-PentaBDE) adopted by the POPRC in November 2007 (UNEP 2007), the committee concludes that a ban of C-PentaBDE could present a technical and legacy issue for the waste sector. Briefly, the issues could be described as the difficulty for the waste operator to separate C-PentaBDE containing articles from those without the substance since most articles are not labelled with information disclosing its content. The other problem discussed in the report is the technical separation of bromine-containing and non-bromine-containing plastic components. At the

time, according to the report, technologies within this field were emerging, expensive and not widely used.

In its risk management evaluation on commercial octabromodiphenyl ether (C-OctaBDE) from October 2008, the committee concludes with identical wording as for C-PentaBDE the above-mentioned problems with unknown content in articles and the difficulties with separation of bromine containing plastic components (UNEP 2008). For both these groups of substances, the review committee recommended the COP to include the substances in Annex A of the convention, banning their use. The recommendations from the committee did not include any suggestion for a recycling exemption.

At the following meeting of the parties, COP 4 in May 2009, the parties decided to list both hexabromodiphenyl ether and heptabromodiphenyl ether as well as tetrabromodiphenyl ether and pentabromodiphenyl ether (UNEP 2009a, 2009b) in Annex A of the convention. Octabromodiphenyl ether in itself was not listed as it was judged to not fulfil the POP criteria, see 5.3. In both decisions, it was after discussions decided to also include a new part to Annex A, part IV and V respectively. These new parts contain a recycling exemption that may allow the recycling of articles that contain or may contain the substances, and the use and final disposal of articles manufactured from recycled materials that contain or may contain the substances provided that the following conditions are fulfilled:

1. The recycling and final disposal is carried out in an environmentally sound manner and does not lead to recovery of the substances for the purpose of their reuse;
2. The Party does not allow this exemption to lead to the export of articles containing levels/concentrations of the substances that exceed those permitted to be sold within the territory of the Party; and
3. The Party has notified the Secretariat of its intention to make use of this exemption

Any further reasoning behind the decision to include these exemptions has not been found in the meeting documents. According to a Swedish representative that attended the meeting (Delvin 2019), the question regarding the need for recycling exemptions was raised by some parties shortly prior to and during the meeting of the parties. The issue had not been investigated in detail prior to the meeting by the POPRC. Therefore, the decision to include the exemption was made based on the discussions held at the COP as a political compromise.

5.2.2 Implementation in former POPs Regulation (EC) 850/2004

Within the EU, the new substances listed in the Stockholm Convention by the COP 4 decisions were implemented in 2010 by amendments to the POPs Regulation: (EU) No 756/2010 and (EU) No 757/2010 (EC 2010a, 2010b). In recital 7 to the latter amendment, the reasoning behind implementing the recycling exemption in EU law is described. The reasons are the following:

> "Taking into account the practical difficulties of identifying materials containing polybrominated diphenyl ethers within a mixed waste fraction and the current lack of comprehensive scientific data on quantities and concentrations of polybrominated diphenyl ethers in articles and wastes, extending the obligation to destroy or irreversibly transform the POP content to these new substances for waste exceeding the concentration limits of Annex IV could endanger existing recycling schemes and thus hinder the sustainable use of resources. This problem was acknowledged by the COP4 and special exemptions were agreed for continued recycling of wastes that contain listed polybrominated diphenyl ethers even if this may lead to recycling of the POPs."

Following the recital, the amendments implement the changes to the annexes of the POPs Regulation allowing articles or preparations from recycled material containing POP listed BDEs in concentrations below those listed in Table 8 to be placed on the market.

Considering that the conditions associated with making use of the recycling exemption for listed BDEs set out in the convention should be followed as described above, the EU must have notified the convention of its intention to use the exemption. This notification document has however not been found during the research for this report. The European Commission has however notified the Secretariat of the Convention that the EU withdraws its previous registration for use of the listed BDE exemption in a document dated 2019-11-28 (EC 2019c).

In a Q&A document from 2009 the Commission related to the amendments implemented in the POPs Regulation, the Commission further elaborates its decision to use the recycling exemptions (EC 2009). In the answer to question 8 in the Q&A document regarding why the 0.1 % (1000 ppm) concentration limit for recycled material was implemented, the answer given by the commission is that it "is introduced to allow continuation of recycling of materials". With the information at hand, it is difficult to categorize this argument as it could imply economic, political or environmental reasons. Table 9 gives an overview of the arguments described above.

Table 9. Overview on the arguments for exemptions under the former POPs Regulation

Category of argument	Description of argument	Counter-argument[1]
Not specified	Continued recycling of material	None identified
Environmental	Sustainable use of resources	None identified
Technical	Difficulty to identify PBDE containing materials	None identified

[1]As used in the evaluated documents. Only if it is clearly indicated, the category of the argument has been possible to identify.

5.3 Assessment of the use and effects of the exemptions in the former POPs Regulation

The following chapters will give a short summary of the main use, which waste fractions that are mainly affected and how the exemptions were used by the recycling industry.

Brominated flame retardants have been used in a wide variety of primarily consumer products. The flame retardants have been available as commercial mixtures with three different degrees of bromination; commercial PentaBDE, commercial OctaBDE and commercial DecaBDE, often abbreviated as e.g. C-PentaBDE (UNEP, 2017). The typical distribution of PBDE congeners in the different commercially used mixtures can be seen in Table 10, taken from a UNEP guidance document on disposal of POP- PBDE (UNEP, 2017). The names of the commercial mixtures are used in the background documents behind the listing of BDEs in the Stockholm Convention but the actual decisions and listings in the Annex is congener specific. It is worth noting that octaBDEs are not regulated on their own as

they do not fulfil the POP criteria. They do however co-occur with hexa- and heptaBDEs in the c-OctaBDE mixture which will have led to an inhibition of their use. Deca-BDE was listed in 2017.

Table 10. The typical distribution of PBDE congeners in the different commercially used mixtures.

Commercial mixture	tetra BDEs (%)	penta BDEs (%)	hexa BDEs (%)	hepta BDEs (%)	octa BDEs (%)	nona BDEs (%)	deca BDEs (%)
C-PentaBDE	24 - 38	50 - 60	4 – 8				
C-OctaBDE			10 - 12	44	31 – 35	10 - 11	< 1
C-DecaBDE						< 3	97 -98

5.3.1 Use of BDEs and relevant waste fractions

On behalf of the European Commission, a consortium of consultants investigated the waste related issues with the in 2010 regulated POP BDE (ESWI, 2011). In their report ESWI concludes that for C-PentaBDE, approximately 95% of all use in Europe was in flexible polyurethane (PUR) foams. The remaining 5% were used in a variety of applications, including PVC plastic, epoxy resins, rubber, paint/lacquers, unsaturated polyesters (UPE), textiles, hydraulic oils and possibly others. The PUR foams were in turn mostly used in automotive interior and upholstery applications (mattresses, car seats, sofas, head rests etc.).

In Figure 3 below, the mass flow analysis for C-Penta-BDE as reported by ESWI is shown. In 2010, the total calculated amount of C-PentaBDE was 355,3 tonnes out of which 72.7 % stemmed from automotive applications and the remaining 27.3 % from upholstery applications. Out of the 334.6 tonnes of C-Penta-BDE that were estimated to end up as waste, 8.7 % were recycled, exclusively from automotive applications.

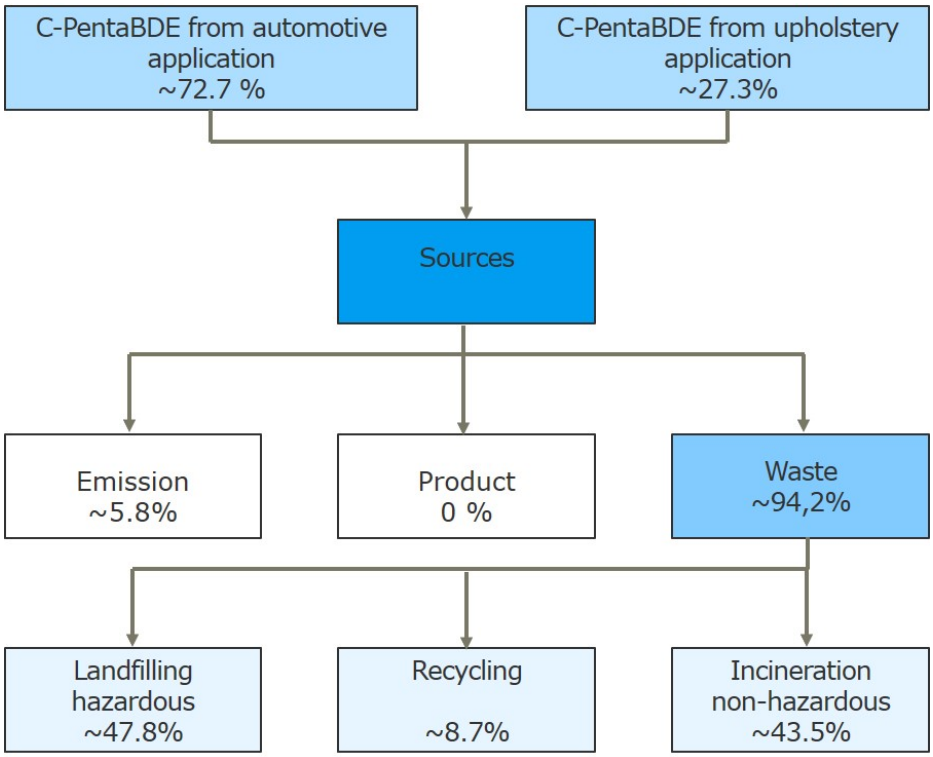

Figure 3. The mass flow analysis for C-Penta-BDE as reported by ESWI(modified). The mass flow was calculated in 2010

Since the majority of C-PentaBDE has been used for automotive applications, end of life vehicles (ELV) is the most relevant waste flow to investigate when it comes to use and effects of the recycling exemption. To assess the effects of the exemptions, stakeholders within the ELV recycling business were contacted, as described more in detail in chapter 5.3.2.

In the corresponding analysis of C-OctaBDE (the commercial mixture containing hexa- and heptaBDEs), the ESWI report concluded that the main use of C-OctaBDE in the EU has been Acrylonitrilebutadiene-styrene (ABS) plastics. This use amounted to approximately 95 % of all C-OctaBDE use and the typical application was housings/casing for electrical and electronic equipment (EEE). A common use for the C-OctaBDE was in the back of cathode ray tube (CRT) TV and monitor casings. The tubes in screens utilizing this technology emits a lot of heat which explains the use of flame retardants.

The remaining 5 % was used in other polymers (HIPS, PBT and polyamide) and other possible uses such as nylon, low density polyethylene, polycarbonate, unsaturated polyesters, adhesives and coatings. The mass flow analysis for C-OctaBDE can be seen in Figure 4 below, original tonnages (ESWI, 2001) has been recalculated into percentage. Only the use in EEE has been taken into account. Out of the 128 tonnes of C-OctaBDE estimated to end up in waste 2010, 17.9 % or 23 tonnes were estimated to end up in recycling operations.

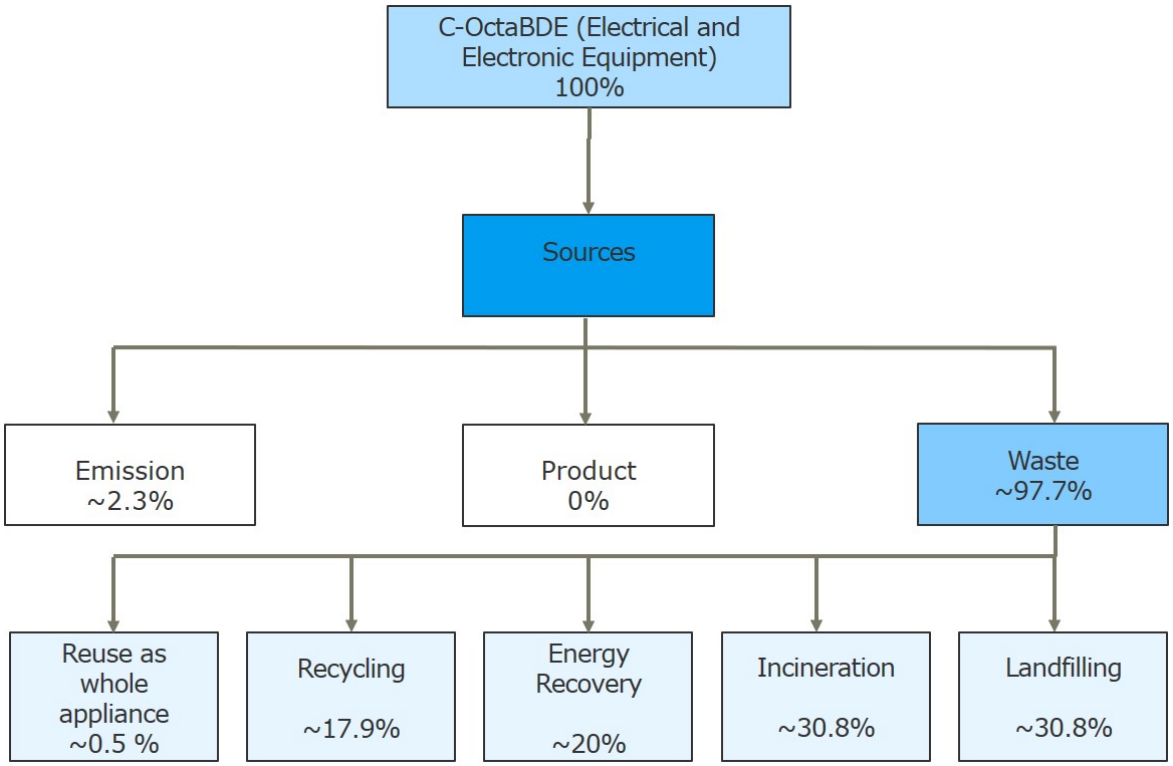

Figure 4. The mass flow analysis for C-OctaBDE as reported by ESWI (modified). The mass flow is based on figures from 2010.

Similarly to the C-PentaBDE, the majority of C-OctaBDEs were used in a well defined product group (EEE) and hence, the most relevant waste flow to investigate when it comes to use and effects of the recycling exemption is WEEE. Therefore, stakeholders within the WEEE recycling business were contacted, as described in the following chapter.

5.3.2 Utilization of recycling exemptions

The European Group of Automotive Recycling Associations has in their input from the stakeholder consultation on PBDEs in end of life vehicles indicated that PBDEs never were a big problem for the industry (EGARA 2020). This can be explained by the vehicle dismantling process and its resulting output, briefly described below.

As mentioned previously, the primary use for PBDEs in vehicles was in the PUR foam used in the interior and in upholstery. These parts of the vehicle are rarely handled or dismantled separately. Instead, they are left in the car hulk that goes to shredding. After shredding, the material undergoes various separation steps to separate e.g. ferrous metals etc. The PUR foam ends up in the shredder light fraction also known as fluff together with glass, metals, rubber, sand, rust, textile fibers and fibers from other materials. Methods to further process this mixture by post shredding techniques into cleaner fractions are available or under development but require a lot of effort and are not always utilized. The fluff, and consequently any of the 2010 regulated POP-BDEs discussed in this report, is according to EGARA either incinerated or landfilled. The disposal method differs between countries, but incineration and landfill are the main options.

Considering the fate of the PUR foams and in accordance with the stakeholder information, it can be concluded that the recycling exemption for BDEs in the POPs Regulation has not been

utilized by the ELV recycling industry. It has for the same reason not had any effects on ELV recycling volumes.

EGARA also points out that already by the time of the inclusion of the POP-BDEs in the POPS Regulation, the levels were falling in the treated ELVs due to a phase out by the automotive industry prior to the ban. Although a few old cars still could contain the POP-BDEs, this would be exceptions and these substances are today considered to be a non-issue. This statement has not been verified by any data on concentrations found in the ELV.

The information from the WEEE recyclers varied between organisations but can be summed up to two different perspectives. Firstly, information from the European Electronics Recyclers Association (EERA) highlights that when the POP-BDEs were implemented in the POPs Regulation, the RoHS Directive (Directive 2002/95/EC) had been in force since July 2006(EERA 2020) and (EC 2003). The RoHS Directive restricted the use of PBDE in electrical and electronic equipment to 0.1% (through the amendment 2005/618/EC) (EC 2005). The WEEE industry was therefore already striving to comply with RoHS since many of the customers buying recycled plastics are in the EEE business and hence must comply themselves. For this reason, a validated screening method had been developed using XRF technology ensuring that the recycled material complied with the 1000 ppm sum PBDE limit in RoHS. The RoHS compliant material was therefore, according to EERA, containing far lower amounts of POP-BDEs than the recycling exemption otherwise would have allowed (up to 1000 mg/kg per individual regulated POP-BDE as explained under 5.1).

For the reason described above, it can be concluded that the exemption for recycled material (derogation 2a) as laid down in the former POPs Regulation was not used by the members of EERA simply because it had been forced to deal with the PBDEs through the implementation of RoHS. For the same reason, it has had no effect on the volumes of recycled WEEE.

As a comment to the above information from EERA, it would however be an exaggeration to claim that the industry didn’t need the exemptions at all. Due to how the former POPs Regulation was structured, without any exemptions the unintentional trace contaminants limit would have been 10 ppm for each regulated BDE in substances, preparations, articles or as constituents of the flame-retarded parts of articles. This would have meant great difficulties for the recyclers and would likely severely reduced the amount of recycled WEEE plastics in Europe. It could consequently be said that the WEEE recyclers were relying on the second derogation in (EC) No 850/2004 (2b, see 5.1) referring to RoHS which allowed them to place the recycled plastics on the market when used in electric and electronic equipment.

The second perspective on how the WEEE recycling industry was affected by the exemptions in the former POPs Regulation comes from the European Recycling Industries Confederation (EuRIC) and is different from the first (EURIC 2020). One stakeholder was of the opinion that until recently, most WEEE recyclers in Europe had not handled the PBDE containing plastics to any great extent since it was common to export it to primarily China. This was common practice for many companies until the Chinese import ban that took effect in 2018. The ban encompasses 16 categories of solid waste including e.g. metal scraps, scrap vessels, compressed piece of scrap automobiles, smelt slag and industrial waste and scrap of plastics (MEE 2018). Since then, the plastic is treated in Europe to a higher degree. Due to the phase out of the POP-BDEs during the 1990s and early 2000s and the short life span of the EEE containing the regulated substances, the WEEE does no longer contain any significant levels of the POP-BDEs as can be seen in recent reports (RISE 2019; SWEREA_IVF 2018). This view is also supported to some extent by the ESWI report (ESWI, 2011) that cites an article from 2010 stating that “most of the C-OctaBDE containing wastes in the EU have already

been treated through the existing waste management infrastructure". The same section also mentions that much of the C-OctaBDE containing ABS plastics has been landfilled or exported.

To what extent the export described above has occurred and furthermore whether the legal situation would have allowed this, has not been investigated further and is outside the scope of this report. It can however be concluded that if this is the case, the recycling exemptions for in 2010 regulated BDEs investigated in this report have not been utilised by the WEEE recycling business. In fact, one stakeholder explicitly stated that the Chinese import ban on plastic flakes has had a greater impact on European recycling rates than the exemption for POP-BDEs.

6 Recycling exemptions in the RoHS Directive

6.1 Description of the exemptions implemented in the RoHS Directive

6.1.1 Exemption for recovered spare parts

Article 4(5) RoHS determines that the restriction on hazardous substances shall not apply to reused spare parts from:

a. recovered from EEE placed on the market before 1 July 2006 and used in EEE placed on the market before 1 July 2016;
b. recovered from medical devices or monitoring and control instruments placed on the market before 22 July 2014 and used in EEE placed on the market before 22 July 2024;
c. recovered from in vitro diagnostic medical devices placed on the market before 22 July 2016 and used in EEE placed on the market before 22 July 2026;
d. recovered from industrial monitoring and control instruments placed on the market before 22 July 2017 and used in EEE placed on the market before 22 July 2027;
e. recovered from all other EEE that was outside the scope of Directive 2002/95/EC and which is placed on the market before 22 July 2019 and used in EEE placed on the market before 22 July 2029.

This exemption applies if:

- reuse takes place in auditable closed-loop business-to-business return systems; and
- that the reuse of parts is notified to the consumer.

The exemption for recovered spare parts as laid down in Article 4(5) RoHS has three distinct requirements which should be fulfilled. These requirements have a considerable effect on the extent to which the exemption can be applied.

Firstly, the exemption has a limited temporal scope for the various types of spare parts. Not all spare parts can be recovered based on this exemption and spare parts recovered on the basis of the exemption cannot be used in EEE indefinitely. In other words, the exemption applies only to a distinct group of spare parts and a distinct group of equipment in which these parts can be used. As such, the exemption seems to provide an opportunity for a distinct category of EEE to be serviced with sufficient spare parts until their use phase has ended.

Secondly, the exemption is only applicable for a distinct type of business model, namely auditable closed-loop business-to-business return systems. The European Commission´s FAQ document states that closed-loop means that spare parts containing the restricted hazardous substances at levels above the maximum concentration may only be resold to other businesses and only within a system where all transfers are registered, documented and tracked. (That is, it should not be sold on the "regular market") (EC 2012). As such, Article 4(5) RoHS excludes the application of this exemption for open trade in spare parts or sale to non-business consumers.

Thirdly, consumers must be notified that the spare part which is used in their equipment is a recovered piece of EEE. In this regard, the European Commission´s FAQ document states that this includes that the consumer is informed about the risk of hazardous substance content. The FAQ states that this could for example be indicated on the packaging (EC 2012).

In practice, the person placing recovered spare parts on the market will have to assess if the exemption for recovered spare parts as laid down in Article 4(5) RoHS is applicable to this EEE. Such an assessment can be considered part of this person´s compliance obligations under RoHS. In this regard, the person is likely to assess whether the envisaged trading arrangement for recovered parts is in line with the requirements of the relevant exemption.[24]

No explicit decision from a competent authority is required in this regard. The main responsibility of the national competent authority is the enforcement of the applicable RoHS obligations.[25] Thus, within the context of its inspection activities, the national competent authority may evaluate the company's assessment of the applicability of the recovered spare parts exemption.

6.1.2 Exemption based on Annex III and IV to RoHS

Another potential mechanism for exemptions from the RoHS substance restrictions can be found in the system related to Annexes III and IV of the Directive. Article 4(6) of RoHS determines that the restriction on hazardous substances shall not apply to the applications listed in Annexes III and IV. Annex III lists a wide range of non-medical and monitoring and control applications which are exempted from the restrictions on substances. Annex IV lists applications exempted from the restrictions on substances, specific to medical devices and monitoring and control instruments (EC 2012). In accordance with Article 5(1) RoHS, the European Commission shall ensure the adaptation of Annexes III and IV to scientific and technical progress. Materials and components of EEE for specific applications may be added to one of the Annexes provided that such inclusion does not weaken the environmental and health protection afforded by Regulation (EC) No 1907/2006 (REACH) and if any of the following criteria is met:

- their elimination or substitution via design changes or materials and components which do not require any of the materials or substances listed in Annex II is scientifically or technically impracticable; or
- the reliability of substitutes is not ensured; or

[24] These conditions are that reuse takes place in auditable closed-loop business-to-business return systems and that the reuse of parts is notified to the consumer.
[25] Article 18 RoHS determines that Member States shall carry out market surveillance in accordance with applicable EU law.

- the total negative environmental, health and consumer safety impacts caused by substitution are likely to outweigh the total environmental, health and consumer safety benefits thereof.

Furthermore, the Article determines that decisions on the inclusion of materials and components of EEE in the lists in Annexes III and IV and on the duration[26] of any exemptions shall take into account the availability of substitutes and the socioeconomic impact of substitution. Decisions on the duration of any exemptions shall take into account any potential adverse impacts on innovation. Life-cycle thinking on the overall impacts of the exemption shall apply, where relevant.

Materials and components of EEE for specific applications may also be removed from one of the Annexes if the conditions mentioned above are no longer fulfilled.

While a large number of applications listed in Annexes III and IV seem to be geared towards exemptions regarding the use of restricted substances in new products, the mechanism of Annexes III and IV can also be used to provide an exemption for the occurrence of restricted substances in recycled material. The box below provides examples of exemptions or applications for exemption which are linked to recycling considerations.

A current example is entry 6b under Annex III to RoHS: *Lead as an alloying element in aluminium containing up to 0,4 % lead by weight.* This entry enables the placing on the market of EEE containing aluminium from recycled aluminium scrap with the specified maximum concentration of lead as an alloy. The preparatory study under which this exemption was assessed indicates that the occurrence of lead in recycled aluminium was an important consideration (BiPRO 2017).

Another interesting case is request n. B-2016 which concerns a request for an exemption under Annex III for *use of recycled PVC for profiles (windows and doors)*.[27] This requested exemption is currently under assessment (BiPRO 2017). If adopted, this exemption would enable the use of recycled PVC containing lead or cadmium (above the limit value of Annex II to RoHS) in the production of frames for windows and doors.[28]

Regarding the manner in which exemptions based on Annexes III and IV can be applied, the European Commission FAQ document states that exemptions are granted for specific substances used in specific applications and not for the whole EEE, nor for a company. Therefore, whoever uses the substances in the specific application can benefit from the exemption (EC 2012).

[26] The maximum duration of an adopted exemption can be 5 or 7 years, depending on the category of EEE for which the exemption is adopted. See in this regard Article 5(2) RoHS

[27] The exemption applied for would concern electric windows and doors which fall under the scope of RoHS.

[28] It is relevant to note that the consultant assessing the application proposed to add to the proposed exemption wording a limit value of 0,1% for lead and cadmium in order to assure that the exemption does not undermine the level of environmental and health protection laid down in the Cadmium restriction in Annex XVII REACH (see in this regard section 4.1).

The European Commission FAQ document furthermore states that exemptions listed on annex III and IV will no longer be generally applicable when:

- Their validity period has expired;
- They are revoked because the conditions set out in article 5(1)(a) are no longer fulfilled.[29]

In practice, the person placing an EEE on the market will have to assess whether a specific exemption under Annex III or IV is applicable to this EEE. Such an assessment can be considered part of this person´s compliance obligations under RoHS. No explicit decision from a competent authority is required in this regard. As in the case of Article 4(5) RoHS, the main responsibility of the national competent authority is the enforcement of the applicable RoHS obligations. Thus, within the context of its inspection activities, the national competent authority may evaluate the company's assessment of the applicability of the recovered spare parts exemption.

6.2 Arguments used for implementation of exemptions in the RoHS Directive

The following analysis will take the complete exemption for recovered spare parts as laid down in Article 4(5) RoHS as a case study. The reason for this is that the arguments on which the exemption have been based seem to concern the general issue of recovery (or re-use) of spare parts of EEE, rather than by a case concerning a specific category of EEE.[30]

The current wording of Article 4(5) RoHS is the result of a number of amendments initially adopted exemption in 2011. This first version of the exemption had the following wording:

> Paragraph 1 (i.e. the restriction on specified substances) shall not apply to reused spare parts, recovered from EEE placed on the market before 1 July 2006 and used in equipment placed on the market before 1 July 2016, provided that reuse takes place in auditable closed-loop business-to-business return systems, and that the reuse of parts is notified to the consumer.

As this first version from 2011 already contained the most important elements of the exemption, its underlying arguments are especially relevant within the context of this study.

An understanding of the arguments for the original exemption requires analysis of the legislative process which preceded its adoption. In this regard, it should be noted that the original amendments to "RoHS 1"(EC 2008) as proposed by the European Commission did not contain a proposal to adopt an exemption for recovered spare parts under Article 4. The European Commission did, however, propose a new Article 4(4) which determines that the restriction on hazardous substances shall not apply to spare parts (i.e. new spare parts) for the repair or to the reuse of the following:

(a) EEE placed on the market before 1 July 2006.

(b) Medical devices placed on the market before 1st January 2014.

(c) In vitro diagnostic medical devices placed on the market before 1st January 2016.

[29] Anyone can apply for revocation assuming they have documentation that can justify it

[30] As will be explained below, the reference to specific categories of EEE in Article 4(5) RoHS are based on the aim to keep the exemption consistent with the more general structure of the Directive.

(d) Monitoring and control instruments placed on the market before 1st January 2014.

(e) Industrial monitoring and control instruments placed on the market before 1st January 2017.

(f) EEE which benefited from an exemption and was placed on the market before that exemption expired.

Two proposals for wording of an exemption for recovered spare were first introduced by the European Parliament in its draft report on the European Commission proposal in 2010 (EP 2010). Table 11 provides an overview of the proposed wording and provided justification for it.

Table 11. Proposals for wording of the exemption for recovered spare parts

European Parliament Report (15.6.2010)		
	Proposed exemption wording	**Justification**
1.	Business to business equipment whereby parts are recovered from equipment put on the market before 1 July 2006 and where the reuse of the recovered parts are traceable and verifiable, the reuse process can be audited to prescribed standards and there use of parts is clearly notified to the consumer. This exemption would be valid for a period of 10 years after the entry into force of the Directive.	Intended to ensure that manufacturers, particularly those making printing and copying equipment, can collect parts of their old machines for re-use in new ones. In many instances the majority of parts in such machines will experience virtually no wear at all during their normal operation and will be as good as new for re-use purposes.
2.	Paragraph 1 shall not apply to the reuse of spare parts recovered from EEE put on the market before 1 July 2006 in equipment placed on the market before 1 July 2016, under the condition that reuse takes place in auditable closed loop business to business return systems, and that re-use of parts is notified to the consumer.	To ensure resource efficiency, the EU needs to further promote re-use. The premature disposal, destruction or substitution of well-functioning and re-usable spare parts, due to the fact that they have been put on the market before 1st July 2006 and do not comply to RoHS restrictions, would cause unnecessary environmental burden. Not allowing this temporary exemption will lead to disposal of the entire equipment including a majority of RoHS compliant parts. As re-use takes place in a closed return system, the end-of-life of these parts will be appropriately controlled and managed.

In its final report on the European Commission proposal, the European Parliament adopted the second version (see Table 11 above) of the proposed exemption wordings, as well as its reasoning (EP 2010).

It becomes clear from the overview that the main arguments for the envisaged exemption are of an environmental nature. The argument seems to be firstly based on the reasoning that the disposal of a whole EEE due to lack of parts for servicing or repair would present an environmental burden. It could be assumed that this environmental burden constitutes inefficient resource management. Secondly, the argument seems to be based on the proposed criteria for applicability of the exemption:

- Limited temporal scope of the exemption (i.e. temporary nature); and
- Closed-loop nature of the exemption.

The European Parliament seems to reason that these two criteria would mitigate negative environmental effects related to the perpetuation of the non-compliant spare parts in the product cycle.

It is interesting to note that the motivation behind the alternatively proposed wording is based on a more technical argument, which concerns the availability of spare parts for manufacturers of machines, with a view to re-use activities.

The current version of the recovered spare parts exemption, as included in the most recent RoHS recast, was adopted in 2017. Again, the amendments to "RoHS 2" as proposed by the European Commission did not contain a proposal to amend the exemption which was adopted in 2011 (EC 2017d). However, the European Commission did seek to align Article 4(4) with the proposed "open scope"[31] of the Directive. This was done by adding a point "ea" which determines that all other EEE that was outside the scope of RoHS and is placed on the market before 22 July 2019 is exempted from the substance restrictions laid down in Article 4(1) of that Directive.

Again, it was the European Parliament which proposed an amendment to the European Commission´s initial proposal with a view to recovered spare parts. Table 12 provides the wording of the proposed amendment as well as its apparent reasoning in recital 6 to the position of the European Parliament (EP 2017).

[31] On 22 July 2019, a final category 11 of EEE described as "Other EEE not covered by any of the categories above" came under the scope of RoHS. As such, RoHS now has an open scope and applies to almost every type of EEE, except for the types or categories subject to exemptions on the basis of Article 2 or 4 RoHS.

Table 12. Proposals for wording of the exemption for recovered spare parts

Position of the European Parliament (3.10.2017)	
Proposed exemption wording	**Recital 6**
Paragraph 5 is replaced by the following: ‘5. Provided that reuse takes place in auditable closed-loop business-to-business return systems, and that the reuse of spare parts is notified to the consumer, paragraph 1 shall not apply to reused spare parts: (a) recovered from EEE placed on the market before 1 July 2006 and used in EEE placed on the market before 1 July 2016; (b) recovered from medical devices or monitoring and control instruments placed on the market before 22 July 2014 and used in EEE placed on the market before 22 July 2024; (c) recovered from in vitro diagnostic medical devices placed on the market before 22 July 2016 and used in EEE placed on the market before 22 July 2026; (d) recovered from industrial monitoring and control instruments placed on the market before 22 July 2017 and used in EEE placed on the market before 22 July 2027; (e) recovered from all other EEE that was outside the scope of Directive 2002/95/EC and which is placed on the market before 22 July 2019, and used in EEE placed on the market before 22 July 2029.	For all relevant EEE categories, as set out in Annex I to Directive 2011/65/EU, the conditions for the exemption of reused spare parts, recovered from EEE, should be clearly specified. Likewise, since exemptions from the restriction of the use of certain hazardous substances should have a limited duration, the maximum validity period for existing exemptions should also be clearly specified for all relevant EEE categories, including for category 11.

It becomes clear from the recital that the European Parliament aimed to specify the exemption for recovered spare parts in line with the various categories of EEE for which an exemption for new spare parts is laid down in Article 4(4) RoHS. The specification seems to be based on arguments concerning the consistency of Articles 4(4) and 4(5) of the Directive. In addition, the main criteria of the exemption (limited temporal scope and closed loop) remain the same. As such, there is no indication that the proposed Article 4(5) RoHS is based on any new arguments apart from the initial environmental ones.

Table 13: Summary of arguments RoHS

Category of argument	Description of argument	Source of argument	Counter-argument
Environmental	The premature disposal, destruction or substitution of well-functioning and re-usable spare parts, due to the fact that they have been put on the market before 1st July 2006 and do not comply to RoHS restrictions, would cause unnecessary environmental burden. Not allowing this temporary exemption will lead to disposal of the entire equipment including a majority of RoHS compliant parts.	European Parliament	None identified
Environmental	As re-use takes place in a closed return system, the end-of-life of these parts will be appropriately controlled and managed.	European Parliament	None identified

[1]As used in the evaluated documents. Only if it is clearly indicated, the category of the argument has been possible to identify.

6.3 Assessment of the use and effects of the exemptions in the RoHS

For this exemption, no specific case study was chosen for further analysis.

7 Main findings

In this chapter, the main findings from the literature review and stakeholder consultations are presented for the selected EU legislation in scope of this project.

7.1 Summary on exemptions implemented in selected EU legislation

The previous sections clearly show that exemptions for recycling under REACH, the former POPs Regulation and RoHS Directive can vary considerably in scope and application in practice. Table 14 below provides a concise overview of the main findings; which substances, articles or mixtures the selected exemptions covers and the method of application of the exemption in practice.

Table 14. Summary of recycling exemptions implemented in the REACH Regulation, POPs Regulation and RoHS Directive

Exemption	Substances, articles or mixtures covered by the exemption	Selected as case study
REACH Regulation (EG) Nr 1907/2006		
Restriction under REACH (Annex XVII): mixtures produced from PVC waste, hereinafter referred to as 'recovered PVC', mixtures and articles containing recovered PVC if their concentration of cadmium (expressed as Cd metal) does not exceed 0,1 % by weight of the plastic material in the following rigid PVC applications: *(See next column)*	Cadmium in specified PVC applications: profiles and rigid sheets for building applications; doors, windows, shutters, walls, blinds, fences, and roof gutters; decks and terraces; cable ducts; pipes for non-drinking water if the recovered PVC is used in the middle layer of a multilayer pipe and is entirely covered with a layer of newly produced PVC in compliance with paragraph 1 of the restriction.	Yes
Restriction under REACH (Annex XVII): Wood treated with CCA (copper, chromium, arsenic) type C that was in use in the Community before 30 September 2007, or that was placed on the market in accordance with paragraph 4: — may be used or **reused** subject to the conditions pertaining to its use listed under points 4(b), (c) and (d), (…)	Arsenics in wood	No
Authorisation under REACH (Annex XIV)	DEHP for formulation of recycled soft PVC containing DEHP in compounds and dry-blends.	Yes

Authorisation under REACH (Annex XIV)	EDC as a recyclable solvent used in closed systems	No
Former POPs Regulation (EC) No 850/2004		
Annex I, Part A, derogation 2(a) (no longer in force)	Substances, articles, preparations and constituents of flame retarded parts of articles containing Tetra-. Penta-, Hexa- or HeptaBDE produced partially or fully from recycled materials or materials from waste prepared for re-use	Yes
RoHS Directive 2011/65/EU		
Article 4(5) RoHS: Provided that reuse takes place in auditable closed-loop business-to-business return systems, and that the reuse of spare parts is notified to the consumer, paragraph 1 shall not apply to reused spare parts: *(see next column)*	Spare parts recovered from EEE placed on the market before 1 July 2006 and used in EEE placed on the market before 1 July 2016; Spare parts recovered from medical devices or monitoring and control instruments placed on the market before 22 July 2014 and used in EEE placed on the market before 22 July 2024; Spare parts recovered from in vitro diagnostic medical devices placed on the market before 22 July 2016 and used in EEE placed on the market before 22 July 2026; Spare parts recovered from industrial monitoring and control instruments placed on the market before 22 July 2017 and used in EEE placed on the market before 22 July 2027; and Spare parts recovered from all other EEE that was outside the scope of Directive 2002/95/EC and which is placed on the market before 22 July 2019 and used in EEE placed on the market before 22 July 2029.	No
Article 4(6) RoHS: Paragraph 1 shall not apply to the applications listed in Annexes III and IV.	All EEE under the scope of RoHS.	No

7.2 Arguments for exemptions under the selected EU legislation

The REACH Regulation works on the basic principle ‘No data, no market‘. This includes that substances shall not be placed on the market without prior registration, followed by evaluation and if relevant authorisation and/or restriction. All four of these processes are, in comparison to the pre-REACH era and also in comparison to other regulations, highly standardized, transparent and well documented. In the context of this project, the unique procedures of the REACH Regulation and the transparent documentation are reflected by the amount of data found and its respective relevance. For example, the absence of alternatives is in many cases an acceptable argument for a specific exemption, in this report categorised as a technical argument. This makes sense, as this needs to be assessed under the authorisation process under the REACH Regulation. The arguments used in the authorisation process for DEHP were political, economic, environmental as well as human health. For the recycling exemption of cadmium both environmental and economic arguments were used. In the authorisation process for EDC-recycling technical, economic, environmental and human health related arguments were used. In conclusion, the standardised and transparent procedures of the REACH Regulation have proven to facilitate the understanding of the implementation of exemptions.

As a contrast to the REACH Regulation, the POPs Regulation and its inclusion of the former recycling exemption for the in 2010 regulated BDEs is less transparent. The possibility for the regulation to include an exemption is dependent on the fact that the exemption exists in the Stockholm Convention. The argumentation behind the introduction of the exemption in the convention is not well documented. It seems like the decision to include the exemptions was based on a compromise in discussions between the parties attending the COP 4 meeting. The corresponding information describing the reasoning behind the recycling exemptions in the former POPs Regulation is also limited. The main arguments that have been identified are: possible technical difficulties to identify PBDE containing material and a concern about the continued recycling of materials and its implications for the sustainable use of resources.

In the case of the RoHS Directive, the arguments which underly the exemption for recovered spare parts are based on environmental considerations linked to resource efficiency. The considerations seem to be based on the reasoning that the disposal of a whole EEE due to lack of parts for servicing or repair would present an environmental burden. As the exemption was proposed by the European Parliament at a relatively late stage of the legislative process, little information is available on the broader context of the adoption of this exemption.

7.3 Use and effects of selected exemptions

7.3.1 Findings regarding DEHP

The findings in this project based on stakeholder information show, that the effects of the authorisation for the recycling of DEHP-containing PVC-waste are mainly negative economic consequences for the recyclers. The stakeholders indicated that the authorisation resulted in higher costs in time and money for the application procedure itself. Furthermore, the authorisation brought competitive disadvantages compared to integrated recyclers that are not obliged to apply for authorisation. In addition, it could be argued that the authorisation influenced the market for PVC in the sense that more virgin material was bought, as it does not have the “problems” associated with legacy substances such as DEHP.

There has been an increase in PVC recycling in recent years but how much of this increase that can be attributed to the authorised recycling of DEHP containing PVC is unknown since

this is mostly classified as confidential business information. It is therefore difficult to determine which effects the recycling exemption has had on recycling. Based on stakeholder information from this project, it can however be argued that recycling of substances that require authorisation according to REACH has not been successful. This is true for at least two of the three original applicants, as one company was liquidated (Vinyloop Ferrara SpA) and the other decided to not reapply for authorisation (Stena Recycling AB) due to decreased demand for recycled PVC. In this context, it is important to highlight that each of the authorisations was granted based on company specific recycling processes and that it is possible that this also has been a major contributor to the outcome described above. The operation of the remaining company Plastic Planet, continuing its recycling is therefore more likely to be economically feasible.

In the case of Stena Recycling AB, a direct consequence of the ceased recycling is an increase in the amount of landfilled DEHP-containing PVC.

The information from the stakeholders also points out a perception of unfair competition in a global context. The authorization procedure only applies for European companies and imported PVC could still contain DEHP. Imported articles have to fulfill some REACH requirements, i.e. restrictions in Annex XVII and information provisions according to article 33 but are not affected by the listing of substances in Annex XIV to REACH.

7.3.2 Findings regarding cadmium

The currently available information concerning recycling of PVC waste and concentration values for cadmium mainly originates from the PVC industry. Furthermore, the most specific and comprehensive projections concerning generation of different types of PVC waste, as well as the development of cadmium concentration in such waste over time, dates back to 2009. Re-assessment of this data is currently ongoing.

PVC waste profiles seems to be the biggest stream which contains concentrations of cadmium. As such, the exemption for cadmium under Annex XVII REACH seems to be most relevant with regard to the recycling and use of this stream.

The data on the recycling of PVC pipes and profiles waste shows a steady increase in volumes, which seem to be in line with the relevant PVC waste generation projections carried out in 2009 (see section 4.3.2.1). A relevant consideration is that the recycling tonnage for PVC waste profiles increased markedly (by 90%) between 2011 and 2012. This is the year in which the cadmium exemption was adopted under the relevant REACH restriction. However, a clear correlation cannot be confirmed within the framework of this project.

Stakeholder Recovinyl indicates that the recycling exemption for cadmium has been an important driver for the increase in recycled volumes of PVC waste. Stakeholders TEPPFA and EPPA indicate that for their sectors, the exemption has merely enabled continued use of recycled material in the production of pipes and profiles.

Indications from the 2009 VITO report and from stakeholders concerning the decreasing concentration of cadmium in PVC waste profiles raise the discussion as to what extent the current practice of the PVC recycling sector is still based or dependent on the limit value of 1000 ppm. The current re-assessment of the 2009 VITO projections may provide up-to-date data on the basis of which conclusions on this matter can be drawn.

7.3.3 Findings regarding BDEs

The main waste fractions that are affected by the exemptions for BDE in recycled material is waste of electrical and electronic equipment (WEEE) and end of life vehicles (ELV). For C-PentaBDE (containing tetra- and pentaBDE congeners) the main use was in polyurethane foams used in automotive applications. Both literature and stakeholder information indicate that the majority of all PBDE containing foams have either been incinerated or disposed of in landfills. The recycling exemptions have not been utilized by the ELV recycling industry and have not increased recycling rates.

For C-OctaBDE (containing hexa- and heptaBDE congeners) the main application was housings/casing for electrical and electronic equipment (EEE). Stakeholder information indicate that the specific exemption for recycled material according to Annex I, part 1, 2(a) was not utilized and has not affected recycling rates because the WEEE recycling industry had implemented measures to ensure compliance towards the RoHS Directive. Compared to the specific exemption for recycled material, RoHS meant stricter requirements for the PBDE content and had been in force for approximately three years prior to the inclusion of BDEs in the POPs Regulation. It therefore looks as if the recycling industry were relying on the second derogation according to Annex I, part 1, 2(b) in the former POPs Regulation allowing BDEs to be used in EEE up to the maximum concentration values according to RoHS, rather than fulfilling the unintentional trace contamination limit of 10 ppm in POPs.

Additional stakeholder information suggests that before 2018 much of the PBDE containing WEEE was not treated in Europe but instead exported to countries outside the EU (e.g. China) and thereby not necessitating the utilization of the exemptions. This is no longer an option but the levels of the PBDEs discussed in this report in WEEE are nowadays usually far below 0.1 %.

7.4 Conclusions

This report shows differences related to the procedures and documentation of the arguments behind the inclusion of recycling exemptions in the investigated pieces of EU legislation. For the authorisation and restriction procedures under REACH, the information is readily available and the reasoning behind the decisions is easy to follow. In the case of both the POPs Regulation and RoHS Directive, the information is scarce as well as more difficult to find. The arguments for the exemptions varies with substance but includes the whole range of categories i.e. technical, economic, environmental, political and human health. The latter is also used as a counter argument. It is therefore difficult to determine a common denominator for the recycling exemptions.

When assessing the use and effects, it is necessary to look at the exemptions individually. Even while doing so, it is difficult to find a common result or opinion in all cases. For DEHP, the available information indicates that the individual company and its strategy or market position has been the most important factor determining the outcome of the decision to apply for authorisation. Of the three companies that originally applied for authorization, one has reapplied and continues the recycling operation. Of the other two, one has been terminated and the other has discontinued its recycling of DEHP containing PVC.

For cadmium, there seems to be differing views within the PVC recycling industry as to whether the exemption as such has led to increased recycling or not. According to certain stakeholders the exemption merely enabled the continued use of recycled PVC containing cadmium. Nevertheless, the available data shows a significant increase in tonnage of recycled

PVC after the exemption was implemented. It can however be concluded that the exemption has been utilized and allowed the recycling of cadmium containing PVC.

For the in 2010 regulated BDEs, stakeholders from both the affected recycling sectors (WEEE and ELV) seems to agree that the former exemption allowing BDEs in recycled material has neither been utilised nor had any influence on the amounts of recycled material in Europe. For ELVs, the affected material (PUR foam) has either been incinerated or landfilled. For WEEE, the recycling industry were working towards complying with the RoHS Directive and the stricter levels laid down therein. Furthermore, export of WEEE to primarily China may have influenced and circumvented the need for the industry to make use of the exemptions.

8 References

BASF, 2015. SEA & AoA - Industrial use as a recyclable solvent and extraction agent in a closed system for purification of 1,3,5-trioxane. Retrieved from https://echa.europa.eu/documents/10162/fe066f13-812c-44ed-96e8-423ecc1739ad

BiPRO, 2015. Study to facilitate the implementation of certain waste related provisions of the Regulation on Persistent Organic Pollutants (POPs). Retrieved from https://ec.europa.eu/environment/waste/studies/pdf/pops_waste_full_report.pdf

BiPRO, 2017. Study to assess 2 RoHS new exemption requests.

Delvin M. (2019) *Personal communication (13.12.2019)*. Swedish Chemicals Agency

EC, 2003. Directive 2002/95/EC of the European Parliament and of the Council of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32002L0095&from=SV

EC, 2004. Regulation (EC) No 850/2004 of the European Parliament and of the Council of 29 April 2004 on persistent organic pollutants and amending Directive 79/117/EEC. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32004R0850

EC, 2005. Commission Decision of 18 August 2005 amending Directive 2002/95/EC of the European Parliament and of the Council for the purpose of establishing the maximum concentration values for certain hazardous substances in electrical and electronic equipment. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32005D0618&from=EN

EC, 2008. Proposal for a Directive of the European Parliament and of the Council on the restriction of the use of certain hazardous substances in electrical and electronic equipment (recast) {SEC(2008) 2930} {SEC(2008) 2931}. 2008. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52008PC0809

EC, 2009. Questions & answers regarding a draft commission regulation amending regulation (EC) No 850/2004 of the european parliament and of the council on persistent organic pollutants as regards annexes i and Retrieved from https://ec.europa.eu/environment/archives/pops/pdf/questions_answers.pdf

EC, 2010a. COMMISSION REGULATION (EU) No 756/2010 of 24 August 2010 amending Regulation (EC) No 850/2004 of the European Parliament and of the Council on persistent organic pollutants as regards Annexes IV and V. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32010R0756&from=EN

EC, 2010b. COMMISSION REGULATION (EU) No 757/2010 of 24 August 2010 amending Regulation (EC) No 850/2004 of the European Parliament and of the Council on persistent organic pollutants as regards Annexes I and III. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32010R0757&from=EN

EC, 2011a. Chemicals/REACH: EU to ban cadmium in jewellery, brazing sticks and all plastics. Retrieved from https://ec.europa.eu/commission/presscorner/detail/en/IP_11_620

EC, 2011b. Commission Regulation (EU) No 494/2011 of 20 May 2011 amending Regulation (EC) No 1907/2006 of the European Parliament and of the Council on the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) as regards Annex XVII (Cadmium) Text with EEA relevance. Retrieved from https://eur-lex.europa.eu/eli/reg/2011/494/oj/eng

EC, 2011c. Directive 2011/65/EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and

electronic equipment Text with EEA relevance. Retrieved from https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX:32011L0065

EC, 2012. RoHS FAQ. Retrieved from https://ec.europa.eu/environment/waste/rohs_eee/pdf/faq.pdf

EC, 2015. Closing the loop - An EU action plan for the Circular Economy. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52015DC0614

EC, 2017a. COMMISSION IMPLEMENTING DECISION of 7.6.2017 granting an authorisation for a use of 1,2-dichloroethane (EDC) under Regulation (EC) No 1907/2006 of the European Parliament and of the Council (BASF SE). Retrieved from https://ec.europa.eu/docsroom/documents/24142

EC, 2017b. COMMISSION STAFF WORKING DOCUMENT EXECUTIVE SUMMARY OF THE IMPACT ASSESSMENT Accompanying the document Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL amending Directive 2011/65/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment.

EC 2017c): Directive (EU) 2017/2102 of the European Parliament and of the Council of 15 November 2017 amending Directive 2011/65/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment (Text with EEA relevance.)Retrieved from https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32017L2102

EC, 2017d. Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL amending Directive 2011/65/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment COM/2017/038 final - 2017/013 (COD). Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1485526057244&uri=CELEX:52017PC0038

EC, 2018. On the implementation of the circular economy package: options to address the interface between chemical, product and waste legislation. Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52018DC0032&from=EN

EC, 2019a. COMMISSION IMPLEMENTING DECISION of 29.1.2019 granting an authorisation for a use of 1,2-Dichloroethane under Regulation (EC) No 1907/2006 of the European Parliament and of the Council (Akzo Nobel Chemicals SpA). Retrieved from https://ec.europa.eu/docsroom/documents/34025

EC, European Commision, 2019b. The European Green Deal. Retrieved from https://ec.europa.eu/info/sites/info/files/european-green-deal-communication_en.pdf

EC, 2019c. Ref. Ares(2019)7344176 - 28/11/2019. Retrieved from http://chm.pops.int/Portals/0/download.aspx?d=UNEP-POPS-EXEM-NOTIF-WDRAW-Octa_PentaBDE-SE-EU.En.pdf

EC, 2019d. Regulation (EU) 2019/1021 of the European Parliament and of the Council of 20 June 2019 on persistent organic pollutants (recast). . Retrieved from https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019R1021&qid=1562680146418&from=SV

ECHA (2010): Guidance on waste and recovered substances. Retrieved from https://echa.europa.eu/documents/10162/23036412/waste_recovered_en.pdf/657a2803-710c-472b-8922-f5c94642f836

ECHA (2011): Guidance on the preparation of socio-economic analysis as part of an application for authorisation. Retrieved from https://echa.europa.eu/documents/10162/23036412/sea_authorisation_en.pdf

ECHA, 2018. Restriction under Article 69(2) on the four classified phthalates in articles. Depending on the outcome of the assessment, the scope of the restriction might be broad or targeted specifically to articles or article groups that are the main contributors

to exposure of the general population. Retrieved from https://echa.europa.eu/de/registry-of-restriction-intentions/-/dislist/details/0b0236e1806e7a36
ECHA (2020a): Applications for authorisation - current consultations Retrieved from https://echa.europa.eu/applications-for-authorisation-consultation
ECHA (2020b): Authorisation List Retrieved from https://echa.europa.eu/authorisation-list
ECHA (2020c): Previous calls for comments and evidence Retrieved from https://echa.europa.eu/previous-calls-for-comments-and-evidence
ECHA, 2020d. Registry of restriction intentions until outcome Retrieved from https://echa.europa.eu/de/registry-of-restriction-intentions
ECHA (2020e): Substances restricted under REACH Retrieved from https://echa.europa.eu/substances-restricted-under-reach
EERA (2020) *Personal communication (10.01.2020).*
EGARA (2020) *Personal Communication (13.01.2020).*
EP (2010) Draft report on proposal for a directive of the European Parliament and of the Council on the restriction of the use of certain hazardous substances in electrical and electronic equipment (recast), 19.3.2010, PE430.424v03-00, Amendments 190 and 191. . Retrieved from https://www.europarl.europa.eu/doceo/document/A-8-2017-0205_EN.html
EP (2017): European Parliament legislative resolution of 3 October 2017 on the proposal for a directive of the European Parliament and of the Council amending Directive 2011/65/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment (COM(2017)0038 – C8-0021/2017 – 2017/0013(COD)). Retrieved from https://www.europarl.europa.eu/doceo/document/TA-8-2017-0362_EN.html
EP (2020): Decision No 1386/2013/EU of the European Parliament and of the Council of 20 November 2013 on a General Union Environment Action Programme to 2020 'Living well, within the limits of our planet' Text with EEA relevance. Retrieved from http://data.europa.eu/eli/dec/2013/1386/oj
EPPA. (2020) *Personal communication (24.01.2020).*
Estense (2018): Crisi Vinyloop. "Così stanno uccidendo le società del riciclo" - Vinyloop crisis. "So they're killing the recycling companies.". Retrieved from https://www.estense.com/?p=603764
ESWI (2011): Study on waste related issues of newly listed POPs and candidate POPs. Retrieved from https://ec.europa.eu/environment/waste/studies/pdf/POP_Waste_2010.pdf
EU_Council (2019): The 8th Environment Action Programme - Turning the Trends Together - Council conclusions. Retrieved from https://www.consilium.europa.eu/media/40927/st12795-2019.pdf
Eunomia (2016): Assistance to the Commission on technological socio-economic and cost-benefit assessment related to exemptions from the substance restrictions in electrical and electronic equipment. Retrieved from https://op.europa.eu/en/publication-detail/-/publication/a3fdcc8c-4273-11e6-af30-01aa75ed71a1
Eunomia_Öko-Institut (2014): Additional input to the commission impact assessment for a review of the scope provisions of the RoHS directive pursuant to article 24(1). Retrieved from https://op.europa.eu/en/publication-detail/-/publication/026306f6-dd03-49fa-9eb9-6e7fcbf73c35
EURIC (2020) *Personal Communication (22.01.2020).*
Fråne (2019): PVC waste treatment in the Nordic countries. Retrieved from https://www.norden.org/en/publication/pvc-waste-treatment-nordic-countries

MEE (2018): Announcement on Adjustment to the Catalogue for the Administration of Import Solid Waste. Announcement No. 6 in 2018. Retrieved from https://www.isri.org/docs/default-source/int'l-trade/china/2018-04-19-mee-announcement-of-2018-2019-banned-items-(en).pdf?sfvrsn=2
NC (2019): PVC waste treatment in the Nordic countries. Retrieved from https://www.norden.org/en/publication/pvc-waste-treatment-nordic-countries
Plasteurope (2018): Closure of operation in Italy / Phthalates issue under REACH brings down European PVC recycling project. Retrieved from https://www.plasteurope.com/news/VINYLOOP_t240095/
Plasticnews (2019): Benvic invests in biopolymers, buys up PVC compounders in Poland and Italy. Retrieved from https://www.plasticsnews.com/news/benvic-invests-biopolymers-buys-pvc-compounders-poland-and-italy
PlasticPlanet (2017): SEA - public report. Retrieved from https://echa.europa.eu/documents/10162/68406c64-ef59-cd49-5a97-e1046bb465f2
Ramboll (2019): STUDY TO SUPPORT THE REVIEW OF WASTE RELATED ISSUES IN ANNEXES IV AND V OF REGULATION (EC) 850/2004. Retrieved from https://ec.europa.eu/environment/waste/pdf/Study_POPS_Waste_final.pdf
Recovinyl (2019): 734,568 tonnes of PVC recycled through the Recovinyl network in 2018. Retrieved from https://www.recovinyl.com/post/734-568-tonnes-of-pvc-recycled-through-the-recovinyl-network-in-2018
Recovinyl (2020) *Personal Communication*. (13.01.2020)
RISE (2019): Mapping and Evaluation of some Restricted Chemical Substances in Recycled Plastics Originating from ELV and WEEE Collected in Europe. Retrieved from http://ri.diva-portal.org/smash/get/diva2:1295690/FULLTEXT02.pdf
RIVM (2016): Plastics that contain hazardous substances: recycle or incinerate? . Retrieved from https://www.rivm.nl/bibliotheek/rapporten/2016-0025.pdf
RIVM_Ramboll (2019): Clean material recycling project - Study Retrieved from https://op.europa.eu/en/publication-detail/-/publication/26e22c04-5b62-11e9-9c52-01aa75ed71a1/language-en/format-PDF
RPA (2014): Socio-economic impact of a potential update of the restrictions on the marketing and use of cadmium. Retrieved from https://op.europa.eu/en/publication-detail/-/publication/482e491d-3b83-4532-9127-896c598006d0
Sadat-Shojai Mehdi and Bakhshandeh Gholam-Reza (2011): Recycling of PVC wastes. Polymer Degradation and Stability, 96, 404. Retrieved from http://www.sciencedirect.com/science/article/pii/S0141391010004556
Stena Recycling AB (2020) *Personal communication* (22.01.2020).
SWEREA_IVF (2018): Decabromodiphenyl ether and other flame retardants in plastic waste destined for recycling. Retrieved from https://www.miljodirektoratet.no/globalassets/publikasjoner/M973/M973.pdf
TEPPFA (2020) *Personal communication* (04.02.2020 & 11.02.2020)
UNEP (2007): UNEP/POPS/POPRC.3/20/Add.1.
UNEP (2008): UNEP/POPS/POPRC.4/15/Add.1.
UNEP (2009a): SC-4/14: Listing of hexabromodiphenyl ether and heptabromodiphenyl ether. Retrieved from http://chm.pops.int/Portals/0/download.aspx?d=UNEP-POPS-COP.4-SC-4-14.English.pdf
UNEP (2009b): SC-4/18: Listing of tetrabromodiphenyl ether and pentabromodiphenyl ether. Retrieved from http://chm.pops.int/Portals/0/download.aspx?d=UNEP-POPS-COP.4-SC-4-18.English.pdf
Vinyloop (2017): SOCIO-ECONOMIC ANALYSIS. Retrieved from https://echa.europa.eu/documents/10162/cc12b498-e2b2-9de6-1846-0209e172df43

Vinylplus (2004-2019): Progress Reports. Retrieved from https://vinylplus.eu/resources/progress-report
VinylPlus (2019a). Retrieved from https://vinylplus.eu/documents/6/60/PVC-recycling-technologies
VinylPlus (2019b): Progress Report 2019. Retrieved from https://vinylplus.eu/uploads/images/ProgressReport2019/VinylPlus%20Progress%20Report%202019_sp.pdf
VITO (2009): Final report: Study on the cadmium content of recycled PVC waste, Study commissioned by Vinyl2010.

Annex I

Description of concepts and definitions

The following meaning to the concepts and definitions are used in this study:

1. "Disposal" is defined in Article 3(19) of the Waste Framework Directive 2008/98/EC as any operation which is not recovery even where the operation has as a secondary consequence the reclamation of substances or energy. Annex I to the Waste Framework Directive sets out a non-exhaustive list of disposal operations.

2. "Preparing for re-use" is defined in Article 3(16) of the Waste Framework Directive 2008/98/EC as checking, cleaning or repairing recovery operations, by which products or components of products that have become waste are prepared so that they can be re-used without any other pre-processing.

3. "Product" is a concept which has various interpretations under EU law. A product could be an object (e.g. a table), but also a less formed material like a liquid or powder (e.g. detergent). Therefore, for the purposes of this study "product" will be understood to encompass:
    a. the definition of "article" under REACH as an object which during production is given a special shape, surface or design which determines its function to a greater degree than does its chemical composition; and
    b. the definition of "mixture" under REACH as a mixture or solution composed of two or more substances.
    c. Nevertheless, the study will only use the concept of "product" if generalization is possible. Whenever more specific formulation is required, the terms "article" and "mixture" will be used in accordance with their definition provided above.

4. "Recovery" is defined in Article 3(15) of the Waste Framework Directive 2008/98/EC as any operation the principal result of which is waste serving a useful purpose by replacing other materials which would otherwise have been used to fulfil a particular function, or waste being prepared to fulfil that function, in the plant or in the wider economy. Annex II to the Waste Framework Directive sets out a non-exhaustive list of recovery operations.

5. "Recycling" is defined in Article 3(17) of the Waste Framework Directive 2008/98/EC as any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes. It includes the reprocessing of organic material but does not include energy recovery and the reprocessing into materials that are to be used as fuels or for backfilling operations.

6. "Recycling exemption" is an exemption which enables the placing of a product on the market despite it containing a restricted substance above a limit value set by the relevant regulation or in a manner (e.g. application) which is otherwise restricted by the regulation.

7. "Secondary raw material" is described in circular economy as the material which after recycling is injected back as raw material into the economy again.

8. “Substance” is defined under REACH as a chemical element and its compounds in the natural state or obtained by any manufacturing process, including any additive necessary to preserve its stability and any impurity deriving from the process used, but excluding any solvent which may be separated without affecting the stability of the substance or changing its composition.

9. “Waste” is defined in Article 3(1) of the Waste Framework Directive 2008/98/EC as any substance or object which the holder discards or intends or is required to discard.

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