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COMMISSION STAFF WORKING DOCUMENT

IMPACT ASSESSMENT REPORT

Accompanying the document

Proposal for a Regulation of the European Parliament and of the Council

amending Annexes IV and V to Regulation (EU) 2019/1021 of the European Parliament and of the Council on persistent organic pollutants

{COM(2021) 656 final} - {SEC(2021) 379 final} - {SWD(2021) 299 final} - {SWD(2021) 301 final}

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1. ANNEX I: PROCEDURAL INFORMATION

1.1. LEAD DG, DECIDE PLANNING / CWP REFERENCES

The preparation of this initiative was led by the Directorate–General for the Environment (DG ENV). It was included as the following item in the DECIDE/Agenda Planning database: PLAN/2019/5397, Update of concentration limit values of persistent organic pollutants in waste - amendments to Annexes IV and V on waste of the Regulation on persistent organic pollutants (following the recast of Regulation 850/2004 (EC)).

The reference in the Commission Work Programme is in ANNEX II (REFIT Initiatives) Point 4.

1.2. ORGANISATION AND TIMING

The Communication on a European Green Deal envisages the proposal of a number of legislative waste reforms, which include amending the annexes of Regulation (EU) 2019/1021 on Persistent Organic Pollutants (POPs), as further specified in the Communication on a new Circular Economy Action Plan. The recently recast Regulation on Persistent Organic Pollutants requires the Commission to review its Annexes IV and V, in which concentration limits are set for certain POP substances in waste.

The purpose of this revision is to **introduce limit values in Annex IV and/or Annex V of the POP Regulation** for new substances whose listing has been agreed internationally under the Stockholm Convention, and **to adapt some existing values to scientific and technical progress** already contained in Annex IV and/or Annex V of the POP Regulation. These limits largely determine the treatment of the waste and, in particular for limits in Annex IV, define whether a waste containing specific POP substances should be disposed of in such a way that its POP content is **destroyed or irreversibly transformed** or, to the contrary, can be subjected to other recovery or disposal operations, including **recycling**.

While under the previous POPs Regulation such adaptations were introduced through Commission implementing acts under the RPS[1] procedure, the recast of the Regulation mandates that this be done via the ordinary legislative procedure. A Commission proposal amending Annexes IV and V needs to be adopted swiftly in view of the deadlines to review values for certain substances as required in the POP recast[2] and in preparation of the next joint conference of the Parties of the Stockholm, Basel and Rotterdam Conventions that were scheduled to take place in Geneva from 19-30 July 2021[3].

The impact assessment relies on relevant information on views regarding hazardous substances in recovered materials and in the circular economy, found in the summary report of the responses to the open public consultation that the Commission carried out on its Communication on the interface between chemical, product and waste legislation adopted in January 2018. Given the high specificity and technical nature of the measure, and due to the availability of consultation input from the referred open consultation, a derogation was obtained from performing an additional open public consultation for this measure. A targeted

[1] Regulatory Procedure with Scrutiny, according to Regulation (EU) No. 182/2011.

[2] For the substances PBDEs and HBCDD.

[3] Due to unfavourable evolution the current COVID pandemic situation the face-to-face segment of Stockholm COP 10 and Basel COP15 has been postponed to June 2022 (tentative date). http://www.brsmeas.org/Implementation/MediaResources/NewsFeatures/COVID19Communication/tabid/8372/language/en-US/Default.aspx

stakeholder consultation was performed as part of the study in support of the impact assessment.

The **Inception Impact Assessment Roadmap** was published on 29 May 2020 and the consultation period concluded on 7 August 2020. Feedback was received from 51 respondents. A summary is provided in section 2.3. of Annex II of this report.

To support the analysis of the different options, the Commission awarded a **support contract** to external experts:

- Study to support the assessment of impacts associated with the review of limit values in waste for POPs listed in Annexes IV and V of Regulation (EU) 2019/1021.

The consultants (RPA/INERIS) worked in close cooperation with the Commission throughout the different phases of the study.

In addition the study team strongly benefitted from another study, carried out in support of a previous amendment of the waste annexes of the POP Regulation, in particular for the mass-flows of substances and waste, done in the context of the recast of Regulation (EC) No. 850/2004:

- Study to support the review of waste related issues in Annexes IV and V of Regulation (EC) 850/2004. Ramboll Environment & Health GmbH. January 2019.

In addition to these two studies, information on relevant substances contained in older studies carried out in support of previous amendments of the EU POP Regulation was also consulted:

- Study on waste related issues of newly listed POPs and candidate POPs. ESWI Consortium. April 2011.
- Study to facilitate the implementation of certain waste related provisions of the Regulation on Persistent Organic Pollutants (POPs). BiPRO. August 2005.

The Inter Service Steering Group (ISSG) for the Impact Assessment was set up by DG Environment. It included the following DGs and services: Secretariat-General (SG), DG GROW (Internal Market, Entrepreneurship, Industry and SMEs), DG SANTE (Health and Food Safety), DG ENER (Energy), DG JRC (Joint Research Centre), DG JUST (Justice and Consumers), DG RTD (Research and Innovation), SJ (Legal Service), DG TRADE (Trade). Meetings were organised between July 2020 and June 2021. Further consultations with the ISSG were carried out by e-mail including initial consultations with an informal pre-ISSG group[4] formed in September 2019, prior to the political validation of the initiative.

Due to the late political validation of the initiative the ISSG could not discuss the Inception Impact Assessment and the main milestones in the process (consultation strategy and main stakeholder consultation activities, planned key deliverables from the support study). These elements were consulted by e-mail, in September 2019 with members of the pre-ISSG group. The ISSG discussed progress of the support study as well as the main elements of the planned impact assessment. The ISSG also discussed the final report of the support study and the draft Impact Assessment report. The views of the group were reflected in the draft Impact Assessment report before its submission to the Regulatory Scrutiny Board.

1.3. CONSULTATION OF THE RSB

[4] The informal pre-ISSG consulted was formed by representatives of DG GROW, DG JUST, DG SANTE, DG JRC, DG TRADE, DG AGRI, DG ECFIN, DG CLIMA, DG ENER and DG RTD

Following a meeting held on 3rd March 2021 with the Regulatory Scrutiny Board (RSB) a a negative opinion was received with a number of indications on how the impact assessment could be improved. The table below presents an overview of the RSB's requests for improvement and how these have been taken into account in the drafting of the draft Impact Assessment report.

RSB comment	How the comment has been addressed
The report needs to better present the international context of the revision of the concentration limits of POPs in waste. The obligations under the Stockholm and Basel conventions need further clarifications, including the need to act by the EU and its margin of maneuver. The report needs to explain better the role of the Basel convention's indicative limit values in this revision.	- A bullet point summary of the most relevant elements of the impact assessment has been included upfront in section 1 "Introduction" including on how the subject of the IA relates to the relevant international conventions. - Section 1.3. "Legal context" has been revised and a new section 1.3.2. has been introduced on the Basel Convention which together with further clarifications in 1.3.3 on the POPs Regulation explain the international obligations of the EU under these conventions, how these translate into obligations under the Regulation and the "room for maneuver" of the Commission. - The text of section 3.1. "Legal basis" has also been amended to better explain the nature of the obligations. - Section 3.2. on "Subsidiarity" has been expanded. - Table 2 under section 5.3 has been modified to explain, for each substance, what are the obligations of the Commission.

RSB comment	How the comment has been addressed
The report should clearly present a hierarchy between its objectives. It should explain where health and environmental considerations take precedence and how far other objectives (such as reduction of greenhouse gas emissions and increased recyclability) can be considered. In this context, it should be clear about how it applies the precautionary principle and how it determines 'acceptable' risk levels for substances when there is no clear scientific evidence. It should better explain what feasibility factors are included in its methodology to fix limit values and why. The report should also clarify how and to what extent it applies the proportionality principle.	- A summary of how the different policy objectives are dealt with and how these are taken into account when applying the methodology that underpins the IA has been presented upfront in section 1. - Protection of human health and the environment is clearly identified as the overarching objective in section 1 "introduction" and in section 4 "Objectives" has been significantly redrafted. Considerations on how the precautionary principle and proportionality are addressed are also summarized in the introduction and in a new sub-section 5.2.2. - A new extensive section 5.2. "Methodology to define limit values" has been included in the impact assessment report to provide a more detailed explanation of the methodology used to propose limit values, how the different objectives are considered and the trade-offs between them. - In addition a more detailed description of the upper and lower limitation criteria used to propose the Annex IV limit values, their meaning and how the methodology is applied has been included in Annex IV of the report as well as in the substance specific chapters of Annex VI where limitation criteria diagrams are provided for each substance. - Adjustments have been done in each of the conclusions sub-sections of each substance-specific chapter in section 6, to better reflect how the application of the methodology links with the proposed preferred policy option (limit value). - A table providing a qualitative scoring for each of the objectives considered, for each of the substances, has been added to section 8.1 "Preferred policy option".

RSB comment	How the comment has been addressed
The report lacks a summary of existing evidence on health and environmental impacts of the different substances. Without such evidence, it is not clear how the choice of POPs' concentration limits in waste is in line with the health and environmental objectives. The report should explain whether and how the presence or absence of consensual scientific evidence influences the choice of limit values.	- A detailed description of the methodology and how it takes into account health-based criteria and the precautionary principle has been provided in an expanded redrafted section 4.2 of Annex IV. - An extensive summary of the human / environmental health based values used, for each of the substances, as part of the methodology to propose Annex IV and V values has been introduced in a new section 4.3 of Annex IV. This also includes how different values have been used to describe different waste treatment scenarios and the rationale of the approach taken in each case. - Limitations in the estimation of these values for relevant POP substances have been outlined in section 1 (introduction) and in section 4.3. of Annex IV. - Limitation criteria diagrams in each of the substance-specific sections of Annex VI have been modified to include the health related upper limitation criterion (when available).
The report should present, where relevant, the cumulative impacts of lowering allowed concentration limits of the concerned POPs in waste. For example, the new limits will increase the amount of waste that has to be either incinerated or disposed in landfills. The report should assess whether the existing waste management centres, incinerators and landfills have sufficient capacity to process the additional waste. Similarly, it should present the cumulative and distributional impacts (resulting from introducing lower limits for all of the substances in scope of the revision) on all the involved economic actors and variables of interest. This includes the impacts on public authorities (e.g. inspections), the amounts of additional greenhouse gas emissions and volumes of recycled material.	- To the extent that the available information allows it, cumulative impact tables for the relevant magnitudes have been introduced under section 8 for the preferred policy option (specifically under 8.2 "Regulatory burden and simplification"). This includes tables covering total and net costs per substance and for the whole proposal; amounts of waste directed to the different treatments, including recycling; cumulative CO_2 emissions; additional cost for users of secondary raw materials and a qualitative description, per substance, of impacts on SMEs and public authorities. - The same section 8.2 now contains an assessment of whether treatment capacities (e.g. via incineration, hazardous waste landfill or non-hazardous waste landfill) would be exceeded.
The report should elaborate on the robustness of the methodology used to establish limit values for POPs in waste. It should clarify to what extent the methodology underpinning the technical study has been peer reviewed and whether it is supported by all stakeholders.	- Considerations on the technical studies, their robustness and use in the international context (i.a. in the POPs Waste Small Intersessional Working Group under the Basel Convention) have been added upfront in the indent on "methodology" under sub-section 1.1 "Main elements of the impact assessment".

RSB comment	How the comment has been addressed
Additional technical comments in the impact assessment quality control report by the RSB report and other changes.	- The table describing the policy options for the different substances under sub-section 5.3.2 has been split into two for greater clarity, separating PCDD/Fs for which the design of options is more complex. - Figure 1 "problem tree" has been modified and fully aligned with the headings in sections 2.1 and 2.2, describing the different problems and problem drivers that the proposal tries to address. - Considerations on enforcement and enforceability of the limit values proposed have been introduced in a new sub-section 1.3.5 "Enforcement" under "Legal context". - Considerations on domestic burning ashes and implications in terms of costs and enforcement have been included in section 2.4 "Who is affected and how?" and in greater detail in section 6.3.3 (on impacts of the policy options for PCDD/Fs). - Some tonnage and cost figures for PCDD/Fs have been adjusted and reviewed based on final report by the consultant. - Additional information added on soil / sediment concentrations of dicofol under section 6.9.3, extracted from the risk profile developed under the Stockholm Convention. - The content and structure of the report have been thoroughly reviewed to avoid unnecessary repetitions and streamline the narrative. Multiple additional smaller editorial changes have been done which are not further detailed here.

Following resubmission on 1st June 2021 a **positive opinion** with some further indications for improvement was received from the Regulatory Scrutiny Board on 29th June 2021. The table below presents an overview of the RSB's additional requests for improvement and how these have been taken into account in the drafting of the Impact Assessment report.

RSB comment	How the comment has been addressed
The report should clarify why its methodology does not differentiate the application of the precautionary principle between substances with or without scientific evidence on health and environmental risks. It is not clear why the methodology selects limit values below the scientifically defined health and environmental risk level.	- Further explanation added in section 1.1 "hierarchy of objectives" explaining use of precautionary principle to go below the determined health-based benchmarks. Additional comments also in section 5.2.1 on how "target function II" is used for this purpose and how this also takes account the limitations that exist for many POPs in the report to derive a reliable health-based reference value.

RSB comment	How the comment has been addressed
For some substances (PFOA, PCDD/Fs, HBCDD, PBDEs) there are analytical potential values that are above the background contamination values or disposal and recovery capabilities. The report should clarify the analytical potential it refers to in this context, as intuitively the analytical potential values should be the lowest considered.	- Differences between analytical potential (A) and background values (B) further explained in section 5.2.1 under "Analytical potential" as well as in section 4.2. of Annex IV, under the same bullet. Therein it is explained that the analytical potential does not reflect the most sensitive quantification limit and therefore values reported in the literature, for specific matrices and analytical techniques can be much lower. - Additional clarification on difference between (A) and (B) values under the limitation criteria tables for HBCDD and PFOA ion sections 6.6.2 and 6.6.6, respectively, of Annex VI. - Additional clarification in section 6.1.3. (PBDEs) regarding the influence of the presence of other brominated flame retardants in the evolution of the quantification limit for the listed PBDEs when determined, based on bromine concentration, using the XRF analytical method.
The report should explain how it applied the proportionality principle when establishing the lower limitation criteria on economic feasibility and on disposal and recovery capabilities. It should clarify why it identified multiple of these criteria for some substances.	- Paragraph added to section 5.2.2 "The precautionary principle and the principle of proportionality". Explanation added about why for some substances several economic feasibility limits are depicted in the limitation criteria diagrams in Annex VI. Clarification also provided as regards elements taken into consideration in economic feasibility assessment, which is case specific and based on (often limited) available information. - Regarding feasibility of treatment operations, the point on "Considerations about treatment capacities" in section 8.2 of the report has been expanded by adding footnotes 189 on landfill capacity and 190 on non-hazardous waste incineration. In addition text regarding hazardous waste incineration and landfilling capacity has been added to that same section.

RSB comment	How the comment has been addressed
The report should explain why it sets the limit value below the highest of the lower limitation criteria for some substances (PBDE, HBCDD, Dioxins and Furans). This would seem to imply that this highest lower limitation criterion is considered irrelevant. The report should also explain why for dicofol it proposes a limit value above the lower limitation criteria.	- The report does not propose limit values below the highest of the lowest limitation criteria, but further explanations added in relevant sections, given sometimes several relevant values are provided and it may not be clear what if the highest lower limitation criterion applied. Section 6.1.4 provides further explanation on how the UTC value for PBDEs is the highest lower limitation criterion for the value of 500 mg/kg initially proposed and how the situation is envisaged to change by the time the second proposed value enters into application five years after adoption of the first. - Further explanation in sections 6.2.3 and 6.2.4 (HBCDD) regarding disposal capacity and economic feasibility (DR and E) being the highest of the lower limitation criteria. - Further explanation of highest of lower limitation criteria for PCDD/F proposed being based on E2 value (economic feasibility). - Explanation added to section 6.9.4 (dicofol) regarding why the "target function II" is not fully applied to lower the proposed value to the highest of the (determined) lower limitation criteria (background).
The report presents a hierarchy of objectives. However, there are inconsistencies in the way it defines its general objective (section 4, 4.1 and 4.3). The report should also clarify why there is a need to balance the health and environmental considerations against the other (economic) objectives, if the former take precedence in the hierarchy.	- Additional text added in section 4.1 under subheading "Transition to high-quality, toxic-free material cycles" and in section 4.3 "hierarchy of objectives" to improve consistency in the definition of the objective. - Two paragraphs have been added in section 4.3 on the need to consider the proportionality principle and how this relates to the general objectives..
While the analysis indicates that the increase in administrative burden for public authorities linked to monitoring and enforcement for individual substances is 'limited', the report should also consider the cumulative effects on administrative burdens for the analysed substances taken together.	- Additional text providing further quantification of possible cumulative enforcement costs for public authorities has been introduced in section 8.2 under table 18 "Cumulative effect on public authorities of preferred option". Contains average enforcement costs for REACH restrictions, as estimated by ECHA.
The report provides an assessment of waste treatment capacity to process the additional hazardous and non-hazardous waste streams that would have to be incinerated or landfilled as a result of introducing lower concentration limits of POPs in waste. However, the presented evidence is either inconclusive (for non-hazardous waste incineration) or absent (for landfills). The report should support the conclusion that "the preferred policy options do not seem to entail a problem of capacity for the waste management sector" with sufficient evidence.	- Further information regarding feasibility of treatment operations has been introduced in the point on "Considerations about treatment capacities" in section 8.2 of the report. Footnotes 189 on landfill capacity and 190 on non-hazardous waste incineration have been added. - In addition text regarding hazardous waste incineration and landfilling capacity has been added to that same section.

2. ANNEX II – STAKEHOLDER CONSULTATION SYNOPSIS REPORT

2.1. OVERVIEW

The Impact Assessment accompanying the review of Annexes IV and V of the Regulation on Persistent Organic Pollutants (POPs) was subject to a thorough stakeholder consultation to ensure that the view from different organisation are duly represented and considered. Given the technical nature of the measure being considered, and its high granularity, the exercise was primarily addressed to professional, academic and industrial/sectorial stakeholders, as well as representatives of the civil society such as NGOs, consumer associations and trade unions.

The consultation has focused on obtaining information on possible environmental and socio-economic impacts resulting from setting limit values for different POP substances in waste, particularly so called **low-POP limit values**[5], at different levels. In addition the objective of the consultation was to address specific information gaps regarding substance mass flows, waste generation and waste treatments, that remained outstanding following previous studies by the Commission on this matter.

As outlined in the Consultation Strategy, the Commission carried out a public consultation on the Inception Impact Assessment report which, due to the exceptional circumstances brought about by the COVID-19 pandemic, lasted 10 weeks. In addition, a **targeted stakeholder consultation** was carried out, comprising all aspects relevant to the Impact Assessment, including socio-economic elements, by means of an electronic questionnaire and interviews with stakeholders **representing key sectors and organisations concerned**.

A derogation from performing the 12-week public consultation prescribed by the Better Regulation Guidelines of the Commission on the proposed measure was granted by the Cabinet of the Commissioner for Interinstitutional Relations and Foresight. The rationale for this exception lies in the fact that a public consultation regarding the societal concern about substances of concern in recycled materials had recently been performed addressing the broader, less technical aspects of this measure and that this information was already available and would be used in support of the current measure. A summary report[6] of that consultation was published on 28 February 2019.

2.2. MAIN OUTCOMES OF THE OPEN PUBLIC CONSULTATION ON THE "INTERFACE" COMMUNICATION

In 2018, the European Commission launched an Open Public Consultation (OPC) on a Communication on the interface between chemical, product and waste legislation, in the context of the Circular Economy (that was adopted in January 2018).

The OPC consisted of a questionnaire aimed at gathering feedback on four issues identified by the European Commission as barriers to achieving a more circular economy:

- Insufficient information about substances of concern in products and waste;
- Substances of concern in recycled materials;
- Uncertainties about how materials can cease to be waste; and

[5] These are the values listed in Annex IV of the POP Regulation.

[6] https://ec.europa.eu/info/sites/info/files/summary-report-public-consultation-chemical-product-waste-legilsation.pdf

- Difficulties in the application of EU waste classification methodologies and impacts on the recyclability of materials (secondary raw materials).

The responses received addressed the broader issue of "substances in concern" (SoCs) present in products and only some mentioned specifically POPs, which can be considered a subset of such substances of concern. Of the 461 total survey responses, 17 specifically referred to POPs. The majority of the information comes from NGO and industry or trade association responses.

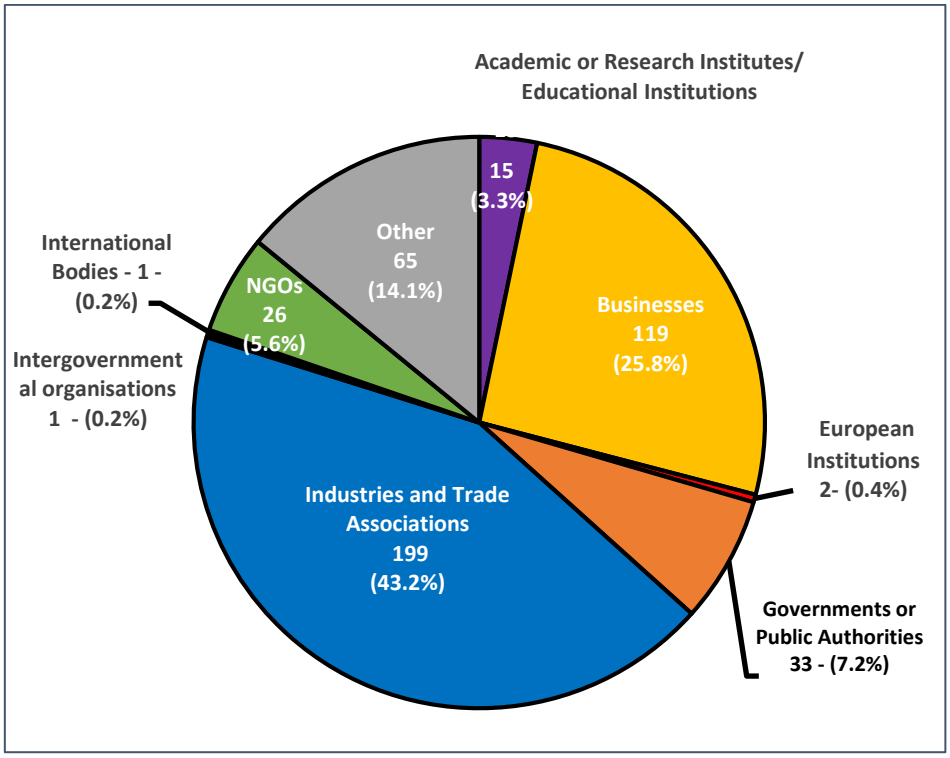


Figure II-1 – Responses to the "interface" OPC, by stakeholder type.

In addition to the answers to open text questions in the questionnaire employed, 36 organisations provided additional information in the form of position papers. These were received from EU Member State Authorities, businesses, as well as industry or trade associations. Table 1 below gives an overview of the responses relative to POPs[7].

Table II-1: Number of survey results relative to POPs

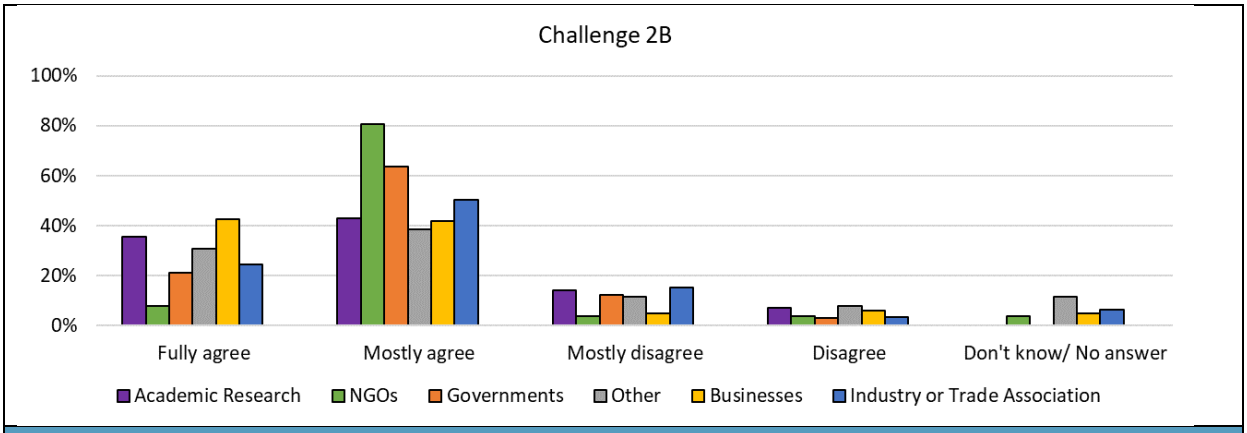
Stakeholder type	Number of responses	Percentage
NGOs	7	41%
Industry or trade associations	5	29%
Government	1	6%
Businesses	1	6%
Academic research	1	6%
Other	2	12%

[7] Although responses that referred specifically to POP substances were relatively scarce it should be noted that the consultation received extensive comments on the broader, less specialised concern regarding the presence "substances of concern" in recovered materials. Further detail can be found in chapter 12 of RPA(2021).

Regarding the inclusion of POPs into the scope of a possible definition of the concept of "Substance of Concern" two definitions were consulted upon, receiving rather spread responses. There was a somewhat higher level of support for the definition "*substances of concern are those identified under REACH as substances of very high concern, substances prohibited under the Stockholm Convention (POPs), specific substances restricted in articles listed in Annex XVII to REACH as well as specific substances regulated under specific sectorial /product legislation".* This definition is supported by all stakeholder groups; however, it is worth noting that industry or trade associations indicate more moderate levels support.

There is a moderate level of support for a definition which states "*substances of concern are all substances identified under REACH as substances of very high concern ('candidate list substances') or listed in Annex VI to the CLP Regulation for classification of a chronic effect."* This definition obtained moderate levels of agreement with industry and trade associations being clearly in disagreement but with strong support from NGOs. It should be noted that under both definitions, substances identified as POPs under the Stockholm Convention would be covered.

The "interface" consultation also asked respondents their views regarding convenience and approaches to **track of substances of concern** (including POPs) in products. The responses revealed a **strong agreement that tracking of SoC in products and in secondary materials should happen by a given date**, not be voluntary and that the nature of the obligations should be commensurate to the what is needed. Figure 2 shows the survey responses related to the tracking of substances.



Survey responses to Option 2B - *sector specific tracking solutions: information on relevant substances of concern should be available to recyclers in a form commensurate to what is required.*
European Commission (2018): Public consultation addressing the interface between chemical, product and waste legislation

Figure II-2 – Survey responses to Option 2B in CPW consultation – Sector-specific tracking solutions.

There was also **very relevant support** to the notion of applying the **same rules about the presence of SoC to both secondary and primary materials**. The question was posed whether "*derogations from rules on primary materials could be made for secondary materials, subject to conditions and to review within a defined time period. Such decisions should be substance-specific and based on overall costs and benefits to society according to an agreed methodology"* or if on the contrary such derogations should not apply.

The two options received a rather spread reply, with some preference towards a situation where derogations from the general principle could be provided, subject to conditions. This

option received greatest support from Governments and businesses (70%), and Industry or Trade Associations (76%) but was strongly opposed by NGOs indicated a high level of disagreement (73%) with such option. As demonstrated by subsequent consultation work this **matter remains controversial** and provides the most polarised views.

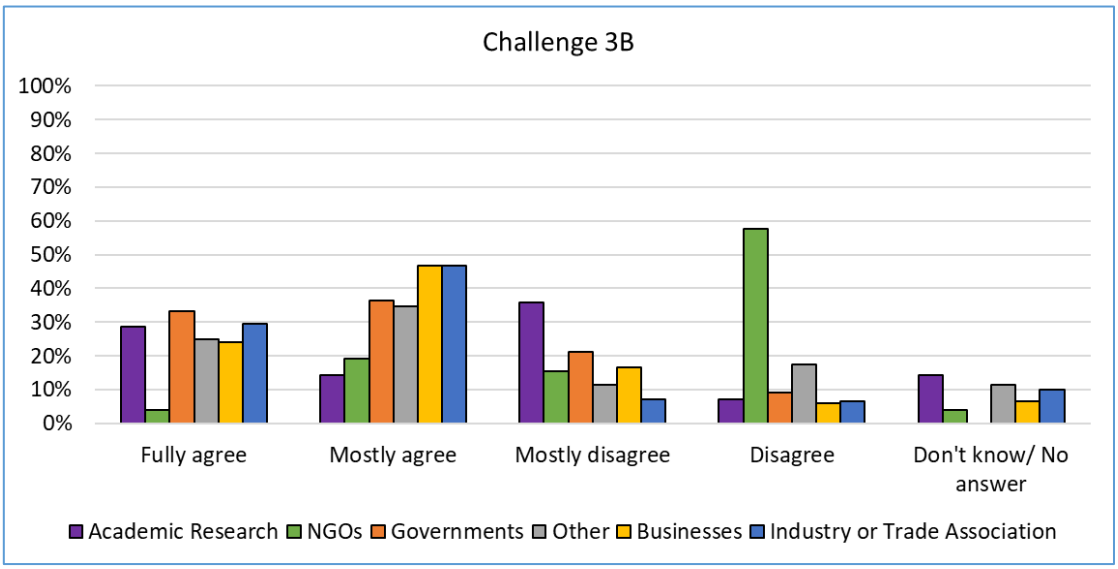


Figure II-3 – Survey responses to Option 3B in CPW consultation – derogations from rules on primary materials could be made for secondary materials, subject to conditions.

2.3. FEEDBACK TO THE INCEPTION IMPACT ASSESSMENT CONSULTATION

The Inception Impact Assessment for this measure was published on 29th May 2020 and ran for 10 weeks until the 7th August 2020. Stakeholders were invited to provide feedback on the proposed revision of limit values for substances in Annexes IV and V of the EU POPs Regulation. In total, **51 responses** were received.

Approximately half (49%) of the responses provided to the consultation originate from business associations and individual businesses. NGOs contributed over one third of responses (35%), with a low response rate from all other stakeholder types (collectively contributing 16% of responses); including academia, EU citizens, public authorities, other and anonymous.

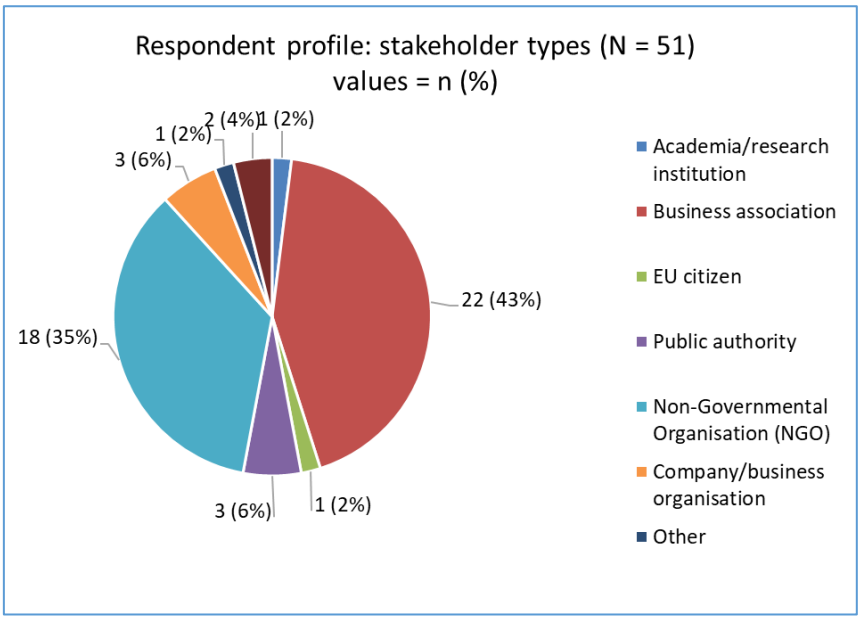


Figure II-4 – Respondent profile to the open public consultation on the Inception Impact Assessment on the amendment of Annexes IV and IV of the POPs Regulation.

There are two types of stakeholders: NGOs which represent a strong campaign position and business associations and companies which primarily represent opinions from within their industry sectors. The analysis of the responses reveals a number of **important recurring themes** which appear throughout the different contributions. These are summarised below. In addition where detailed, substance-specific information or figures were provided, these were used and are documented in relevant substance chapters of the supporting study by RPA(2021) [*Study to support the assessment of impacts associated with the review of limit values in waste for POPs listed in Annexes IV and V of Regulation (EU) 2019/1021*. European Union 2021. ISBN 978-92-76-41943-3] and duly considered.

- **POPs and the circular economy**. Arguments related to the need for consistency between the goals of achieving a circular economy and the need to destroy POPs are present in a number of responses. According to many responses, particularly from NGOs the ***recycling of waste containing POPs is incompatible with a safe circular economy***. This argument prioritises the removal of POPs from within the supply chain over the potential benefits associated with recycling such products.

  Industry responses provide a more nuanced view and highlight that EU policies which strive for a 'toxic free environment' and also for more recycling often point in **contradictory directions** which results in waste operators finding themselves in a situation where rules are not predictable and not always practicable. Two associations indicated that more public support should be provided to **foster new investments in waste sorting and decontamination** as this would allow for more recycling.

- **Principles of the Stockholm Convention.** Campaign respondents, mostly NGOs, indicated that in their view the European Commission **should pay greater attention to the principles of the Stockholm Convention** (destruction of POPs in waste) and that current limit values **enable POPs to remain in recycled products**. These stakeholders also indicated their doubts about the capacity of current recycling processes to safely remove POPs from the recycled materials and that the risk of continued presence of POPs in products is not acceptable.

- **Appropriateness of current limit values**. Respondents provided very split views regarding the appropriateness of current Annex IV limit values. NGOs responses clearly indicated that in their view **these were too high and proposals for lower, much stricter limit values** were made. Substances such as dioxins and furans were frequently mentioned as a source of concern and where action was necessary. On the other hand **industry views strongly supported that current values would be maintained**, as further action was not seen necessary. No respondents requested the relaxation of the current limit values for POPs in waste.

    - **Lowering limit values for POPs in waste**. The most prominent idea by 21 campaign responses (NGOs) is the lowering of current POPs limit values to what these responses believe to be 'scientifically and environmentally sound' levels. Human health and environmental impacts are cited as the fundamental reason to justify the elimination of POPs from waste streams and recycled materials.

    - **Current limit values are appropriate.** The most prominent position of the industry is to maintain values in the Regulation and, in particular, current Annex IV limits in waste at the same levels. According to the responses, lowering of limit values for POPs in waste may result in a number of negative business impacts and render the recycling of waste far less viable.

      This is due to fears that lowering limit values of POPs in waste will create a scenario in which operators are unable to measure and sort according to these low values, and subsequently **increase the level of waste being directed for disposal**.

- **Environmental and health impacts**. A number of responses focus on the environmental impacts of lower low POP content limits, highlighting two issues: the **environmental benefits in terms of destroying POPs** and **negative impact of increasing CO_2 emissions** due to the diversion of waste to incineration. The favourable health impacts associated to the review of POP limit values in waste were mentioned only by campaign respondents. Specific concerns were raised by NGOs about a number of specific issues, in particular the use of fly-ashes contaminated with dioxins on land. This matter has been specifically considered in the Impact Assessment.

- **Traceability issues.** A point of convergence amongst campaign and non-campaign responses is that the absence of information available to trace POPs in waste is highly problematic. Respondents request **greater investment into the tracking** of historic uses and content levels of POP substances in products and waste, as well as greater investment into market surveillance of imports from outside the EU.

- **Export of POP waste.** NGO responses stressed the importance of introducing **lower POP limit values as a way of limiting the export of POP-waste from the EU to third countries**, especially to developing countries, where standards of treatment are often poorer and there is greater likelihood of pollution and adverse human health effects. The idea that the **EU should take responsibility for the treatment of its waste** was highlighted. In addition, some respondents expressed concern about the formation and release of unintentional POP substances, (eg dioxins) as a consequence of some treatment processes, such as incineration.

- **Imports.** Some respondents also point out issues regarding the identification and control of waste imported from outside of the EU. One campaign respondent

(academia) made the case that the Commission needs more effective control mechanisms in place to establish acceptable and compliant limits for POPs in waste at the point of import. Further to this, one non-campaign respondent (public authority) concurred that it is **essential to avoid the contamination of recycled materials via imports** where imported products from outside the EU may contain high levels of restricted substances.

- **Technological needs.** A large proportion of campaign responses (11 NGOs and 1 anonymous) explicitly state the **need for greater investment in destruction technologies other than incineration**. In particular, campaign respondents indicated a high level of distrust over the incineration of waste containing POPs. This is due both to the perceived environmental cost in terms of CO_2 emissions, as well as to distrust that incineration effectively destroys (all) the POPs substances contained in waste. Contrary to this, some respondents representing the waste management industry **explicitly supported for the continued use of incineration** as the best and most effective means to dispose of non-recyclable waste.

It is clear from the responses received that **NGO and industry responses differ widely in their views** on how to deal with POP substances in waste, with the former advocating for **much stricter limit values** and alternative destructive treatments to incineration. Contrary to this position, most industry contributions defend more nuanced view, proposing **maintaining the *status quo***, so as not to compromise current recycling activity and defending the use of incineration, when recycling is not possible and waste has to be destroyed.

2.4. TARGETED STAKEHOLDER CONSULTATION

A questionnaire consultation was carried-out among stakeholders in the form of a digital survey distributed to key stakeholders. The survey was divided into **six types of questionnaires** and distributed to stakeholders with an interest in this study:

Questionnaire 1: Waste management associations
Questionnaire 2: Waste management companies
Questionnaire 3: Secondary raw material users
Questionnaire 4: Member state authorities
Questionnaire 5: NGOs & independent experts
Questionnaire 6: Equipment manufacturers

The questionnaires were available to download in Word document format as well as via the online tool, Smart Survey from the project website (https://popsinwaste.eu/consultation/questionnaires). Invitations to participate were sent directly to stakeholders via e-mail.

The study team disseminated survey invitations to 271 key stakeholders of which around **40 provided a response**. These included the following organisations:

- Industry associations: Confederation of European Waste-to-Energy Plants (CEWEP), European Electronics Recyclers Association (EERA), European Recycling Industries' Confederation (EuRIC), European Union for the Responsible Incineration and Treatment of Special wastes (Eurits), European Waste Management Association (FEAD), Secondary raw materials, collection and processing Association of Croatia (HGK), Hazardous Waste Europe, Plastic Recyclers Europe, WeeRec;
- Waste management companies: five companies submitted a completed questionnaire;

- Secondary raw material users: European Automobile Manufacturers Association (ACEA), Energy Networks Association, the European Cement Association (CEMBUREAU), Fachvereinigung Polystyrol Extruderschaum;
- Public authorities from Croatia, Finland, Germany, Lithuania, Luxembourg, the Netherlands, Poland, Portugal and Sweden;
- NGOs and independent experts: Arnika, International Bromine Council (BSEF), German Roofing Association, HBCD Industry Group & European Manufacturers Association of Expanded Polystyrene (EUMEPS), International Pollutants Elimination Network (IPEN), Pro 3R, ToxicoWatch; and
- Equipment manufacturers: European Suppliers of Waste-to-Energy Technology (ESWET) and a private company.

In addition to the online survey, 11 major telephone interviews were held with eight organisations (and sometimes their members) including CEWEP, EERA, ETRMA, EuRIC, HBCD IG, IPEN/Arnika, Hazardous Waste Europe and ToxicoWatch.

Extensive e-mail exchanges on specific issues have taken place with a large number of stakeholders. In fact, due to the highly technical nature of the issues analysed in this report, the study team and consultees often opted for email communication instead of telephone interviews. A very large number of other documents (position papers, studies/reports, datasets, etc.) were also provided to the consultants by stakeholders consulted for this study.

The following table provides a breakdown of response frequencies to each questionnaire in the survey.

Table II-2: Summary of response distribution by stakeholder type

Stakeholder type	Distribution of responses
Waste management associations	26%
Waste management companies	14%
Secondary raw material users	11%
Member state authorities	23%
NGOs & independent experts	17%
Equipment manufacturers	9%
Total	**100%**

Waste management associations, and collectively waste management companies make up the majority of responses to the survey (making up 40% of responses). However, it is worth noting that Member state authorities rated second as the respondents providing most answers, followed by NGOs and independent experts, both within a similar frequency. Equipment manufacturers and secondary raw material users provided relatively few responses to the survey.

However, it is important to recognise that each stakeholder was provided with a questionnaire with tailored questions that provided the distinct perspective of each stakeholder group.

The questionnaires[8] provided detailed feedback on the organisations responding, on relevant waste streams and presence / concentrations of POPs in waste, on treatment operations, on the use of secondary raw materials, on sampling and analytical methods, and on expected impacts of the different Annex IV values that were consulted upon.

[8] The different questionnaires are available on the web. https://popsinwaste.eu/consultation/questionnaires

The information obtained is integrated in the chapters for the different substances in RPA(2021) and, in particular, in those describing the baseline (material flows, waste treatments, final disposal) and in sections describing impacts of final treatment outcomes, on secondary raw material users and on public authorities.

3. ANNEX III: WHO IS AFFECTED AND HOW – OVERVIEW OF COSTS AND BENEFITS

3.1. DIRECT AND INDIRECT BENEFITS

The table below summarises the **direct and indirect benefits** estimated to arise from the **preferred policy options** to introduce or amend Annex IV limits for 9 substances in the proposed amendment of the POP Regulation. For the reasons explained in sections 1.2.2 and 5.2 of the impact assessment, no specific impacts are expected from the introduction of limit values in Annex V. Consequently all impacts referred to below refer to the preferred option for the different Annex IV values.

I - Overview of Benefits (total for all provisions) – Preferred Option(s)		
Description	**Amount**	**Comments**
Direct benefits		
PBDEs		
Reduced incidence of IQ loss / intellectual disability and cryptoquidism in children and the general population.	A fraction of €10 bn / yr healthcare costs associated to PBDE are expected to be saved. Allocation of these savings to a precise period in the future is not possible with any level of precision.	Continuing widespread contamination of PBDEs is estimated have EU human health costs of around €10 billion (primarily due to IQ loss/intellectual disability and cryptorchidism. Allocation of savings specific to emission reduction associated to this measure is not possible. Under the preferred implementation of option Option 3 (delayed to 2027) the amounts are PBDEs destroyed range from 10 – 180 t. Avoided releases to the environment of PBDEs during service-life occurring in the next lifecycle of the (avoided) recyclate are estimated to be of between **10 – 150 kg** PBDEs.
Reduced worker exposure	No information to allow quantification of this health benefit.	Reduction in exposure to PBDEs for workers working with sorted low-bromine fraction (eg in the compounding and extrusion to produce post-consumer recyclate).
HBCDD		
Reduced HBCDD emissions to the environment. Reduced adverse impact on human health and ecosystems.	Not possible to quantify.	Reduction is likely to materialise in the future, as average concentrations of mixed EPS/XPS waste reduce due to increased presence of "clean" demolition material.
Dioxins & Furans (PCDD/Fs)		
Reduced PCDD/Fs emissions from ashes from domestic burning of wood and coal and from biomass ashes no longer used in agricultural soil, in geotechnical applications or	50 - 200 g TEQ PCDD/Fs emissions avoided[9].	Emissions and adverse effects in humans due to accumulation and exposure to dioxins via the food chain is avoided when these ashes are separately collected and not applied on land, especially

[9] According to BiPRO (2005) the estimated total generation of PCDD/Fs in EU-25 was of 20 kg/year, of which about 25% was released to the atmosphere and 75% onto waste. See pg. 32. https://ec.europa.eu/environment/waste/studies/pdf/pops_waste_full_report.pdf

construction. Also reduced emission from amount no longer disposed in non-hazardous waste landfills.		agricultural land.
Dioxin-like PCBs		
More comprehensive coverage of health risks associated with dl-PCBs (given they will be specifically accounted for).	Cannot be quantified but positive.	Integrating dioxin-like PCBs in the group limit value for PCDD/Fs addresses more precisely the risks of these substances which act via a common mechanism of action. Given that the ratio of dl-PCBs to PCDD/Fs (expressed as TEQ) in some waste streams such as WEEE/ELV and especially ashes, seems to be about 1:10 a 10% increase in control / protection could be argued. For all other aspects see section of PCDD/Fs.
Short-chain chlorinated paraffins (SCCPs)		
Reduced emissions of SCCPs from service life of articles not made from recycled rubber containing SCCPs.	The **maximum additional destruction of SCCPs** over the 2021-2035 will be of 690 t with **maximum annual amount of 180 t.**	Environmental and human health benefit from reduced emissions of SCCPs in rubber associated from removing 690 t of SCCPs cannot be calculated. It can be assumed that a fraction of the SCCPs present in the rubber that is incinerated **would be released during its service life** in articles if recycled.
Perfluorooctanoic acid, its salts and related compounds (PFOA)		
Reduced emissions leading to reduced human exposure.	PFAS exposure estimated to have a health cost of between **52 – 84 bn €** per year **in** Nordic countries. Impossible to quantify. Some reduction due to diversion of some textile waste from recycling and landfilling to incineration.	Reduced incidence of associated cancers, reproductive and thyroidal effects in human. Actual benefits probably limited given a large amount of PFOA containing waste will probably already have been disposed in landfills or incinerated. Given the very high persistence and deleterious effects of these substances all efforts to limit remaining sources of emissions are to be undertaken.
Reduced emissions leading to reduced environmental exposure.	€821 million to €170 billion per year remediation costs based on assumptions of current PFAS exposure estimated by the Nordic Council of Ministers (legacy plus PFAS currently in use).	Reduced incidence of intergenerational toxicity in fish and toxicity to freshwater algae and other aquatic organisms. Reduced PFOA induced in sexual maturation and pubertal timing, changes in mammary gland development and induction of a variety of tumours.
Perfluorohexane sulfonic acid, its salts and related compounds (PFHxS)		
Same assessment as for PFOA, its salts and related compounds.		
Pentachlorophenol and its salts and esters (PCP)		
Reduced emissions leading to reduced exposure of humans via the environment.	About 500 t of PCP will be destroyed until 2032.	Introduction of the limit ensures current treatment of wood (and textile) waste by incineration will continue.
Dicofol		

Given no waste streams containing dicofol have been identified in the EU no impact is expected from the introduction of limits in Annex IV and V. Consequently no direct benefits are expected beyond the fact that if dicofol contaminated waste were to arise or be generated in the future (eg in the restoration of a contaminated site), limits determining the management of this waste would be available and in force in the POP Regulation.
Indirect benefits
Not applicable

3.2. DIRECT AND INDIRECT COSTS

The table below indicates the **direct and indirect costs** that will arise from the **preferred policy option** to amend Annex IV of the POP Regulation for different stakeholder groups: citizens/consumers, businesses and administrations. The table also specifies whether these costs are one-off or recurrent.

As explained in sections 1.2.2. and 5.2 of the impact assessment no impacts, and therefore no costs are expected from the changes proposed to Annex V. This is because such limits are **very rarely applied** and, in practice, would only result in some waste being (potentially) directed for disposal to underground storage in a hazardous waste facility rather than in a hazardous waste landfill.

II - Overview of costs – Preferred option(s)							
		Citizens/consumers		Businesses		Administrations	
		One-off	Recurrent	One-off	Recurrent	One-off	Recurrent
PBDEs	Direct costs		Potential increase of costs to consumers if the vehicle and EEE producers that place them on the EU market internalise the costs incurred by recyclers, if passed on to the producers in accordance with the EPR, into the product price.	Recyclers: (30 specialised facilities) Investment in improving detection / sorting equipment. 6 – 12 M€ (assumed 50% of recyclers will have to do this). **Maximum 800 k€** per company. Expected in 2026-27 prior to entry into application of the revised Annex IV limit.	Recyclers: 7 M€ in incineration costs (average 260 €/ton) for waste plastic recycled and that previously landfilled (155€/ton, assumed 50/50 distribution hazardous waste landfill / non-hazardous waste landfill).For the whole period 2027-2035. Revenue loss for recyclers of 4 M€ due to loss of previously recyclable material that was placed on the market. Landfill operators: 3 M€ revenue loss. Over 2027-2035**.** Users of secondary plastics Additional costs of 6 M€ (2027 – 2035) to substitute recycled plastic with primary plastic. Cost spread over many companies so impact potentially small.		Possible loss of revenues from taxation of waste deposited in landfill in some Member States (which is diverted to incineration). Quantification not possible but impact estimated to be small.
	Indirect costs		Increased CO_2 emissions of about 74,000 t over period 2027-2035 with associated fraction of costs related to consequences of warming of the earth. It is impossible to quantify these but estimated to be small given these emissions are only 0.0003% of GHG emissions in 2018. Possible increased emissions of polybrominated dibenzo-p-dioxins and dibenzofurans (PBDDs/PBDFs). Impact and costs likely small but impossible to quantify.				
HBCDD	Direct costs			Purchase of hand-held XRF analytical equipment for on-site monitoring of bromine (as proxy of HBCDD). 30,000 € per device.	Potential additional waste management costs for demolition operators and construction / demolition contractors resulting from diversion of 0.2% (640,000 t)		Potential increase in enforcement / monitoring activities.

II - Overview of costs – Preferred option(s)							
		Citizens/consumers		Businesses		Administrations	
		One-off	Recurrent	One-off	Recurrent	One-off	Recurrent
					of all C&D waste from non-hazardous waste landfill to hazardous waste landfill due to contaminates with EPS/XPS containing HBCDD. This estimation is **highly uncertain.** 0.64 Mt / year mixed C&D waste results in estimated **additional** costs **135 M€/year** "This is based on an additional landfill cost of 210 €/ton. Cost of HW landfill 260 €/t. Cost of non-HW 50 €/ton.). Additional testing / monitoring costs.		
	Indirect costs						
Dioxins & Furans (PCDD/Fs)	Direct costs	-			Costs to biomass power production plants resulting from diversion of 27,000 – 110,000 t / year of fly ash to hazardous waste landfill or underground storage (previously used in agriculture or sent to non-hazardous waste landfill). **Additional Waste management cost** estimated at**: 6 – 24,8 M€** / year on operators of biomass plants. (average 260€/t for disposal in hazardous waste landfill vs 50€ cost of disposal in non-hazardous waste landfill). Based on the estimated mix of 70% diverted from non-haz landfill and 30% from agriculture / construction, average extra landfill cost is estimated to be 225 €/t. Loss of (potential) revenue to producers of fly ashes may exist but could not be estimated.		Implementation and maintenance of **separate collection system of ashes** from domestic burning of wood and coal[10]. **40 – 159 M€** / year additional cost of managing separately collected ash as hazardous waste (181,000-723,000 t) sent to hazardous waste landfill or underground storage (previously used in agriculture or sent to non-hazardous waste landfill). 36,000-145,000 t of this ash can no longer be used in agriculture (loss of mineral resources). This cost will be borne by

[10] No reference is made to separate collection systems established for such domestic burning ashes in the study "Guidance for separate collection of municipal waste" (2020) https://op.europa.eu/en/publication-detail/-/publication/bb444830-94bf-11ea-aac4-01aa75ed71a1/language-en/format-PDF/source-133422972 carried out in support of the Commission Notice on Separate Collection of Hazardous Household Waste. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020XC1106%2801%29

II - Overview of costs – Preferred option(s)							
		Citizens/consumers		Businesses		Administrations	
		One-off	Recurrent	One-off	Recurrent	One-off	Recurrent
					Additional testing costs for biomass ashes and other waste such as fly ashes and sewage and biowaste compost. Individual test costs about 410 €/sample. Overall additional testing costs per waste stream / sector could not be estimated (given high number of installations involved and lack of knowledge of testing strategies to be applied for each). **0.5 – 2 M€** additional costs to agriculture and to construction as a result of substituting ashes for primary raw material. Increased CO_2 emissions of **2,5 - 15 kt / year** with associated fraction of costs related to consequences of warming of the earth. This can be expected to represent a very modest impact.		municipalities and ultimately the citizen via taxation. average 260€/t for disposal in hazardous waste landfill vs 50 € for disposal in non-hazardous waste landfill). Based on estimated diversion of 80% from non-haz waste landfill and 20% from agriculture, the estimated additional cost per ton is 220 €. Note: As explained in section 6.3.4 of the report, the lower estimate provided in terms of domestic ashes diverted, and their associated cost, are considered a more likely estimate of the impact, although, given the limited analytical information, uncertainties are high.
	Indirect costs						
Dioxin-like PCBs	Direct costs		See section on PCDD/Fs.		See section of PCDD/Fs Possible increase in testing costs to waste oil recyclers due to inclusion of dl-PCBs into group limit for PCDDs. Under the preferred option 3 selected (0.005 mg TEQ/kg) this impact is expected to be small due to only sporadic control checks on incoming oils and not systematic testing expected to be necessary.		See section on PCDD/Fs.
	Indirect costs						

II - Overview of costs – Preferred option(s)							
		Citizens/consumers		Businesses		Administrations	
		One-off	Recurrent	One-off	Recurrent	One-off	Recurrent
Short-chain chlorinated paraffins (SCCPs)	Direct costs				Extra waste management total costs over 2021-2035 of **1.7 – 16.2 M€** for recyclers dealing with rubber from conveyor belts used in mining, which can no longer be recycled. The low estimate is based on a scenario where only SCCP contaminated rubber from mining conveyor belts is disposed of by incineration. The high figure results from assuming that no sorting is possible and all mining conveyor belt rubber will be incinerated. Users of secondary rubber, having to use primary rubber would incur in additional estimated average costs of 500 €/t, resulting in increased costs of €2.3-26 million over 2021-35. Additional testing costs which will vary depending on testing regime and have not been reliably estimated. Testing costs for SCCPs. 200 – 300 € per sample sent to the laboratory.		Potentially additional (limited) enforcement costs associated to new limit.
	Indirect costs						
Perfluorooctanoic acid, its salts and related compounds (PFOA)	Direct costs				Some diversion of textile and carpet waste from recycling to disposal (incineration / landfill). Amounts and costs cannot be estimated given the currently very limited development of the textile recycling sector. Potential adverse impact in the creation of employment in textile recycling sector due to reduced availability of material. Additional PFOA testing for textile		Potentially additional (limited) enforcement costs associated to new limit. Administrative costs for enforcing a restriction estimated by ECHA to be 55,600 € per year.

II - Overview of costs – Preferred option(s)							
		Citizens/consumers		Businesses		Administrations	
		One-off	Recurrent	One-off	Recurrent	One-off	Recurrent
					recyclers. Hundreds of thousands to a few million Euro costs estimated. High uncertainty in all estimations due to very limited information.		
	Indirect costs		For each tonne of textile material recycled there is an estimated saving of 8 t CO_2-e. Assuming there will be some diversion from recycling to incineration (or landfill) this will have an associated, presumably small climate impact and its associated economic, social and environmental impacts. This is impossible to quantify with the available information.				
Perfluorohexane sulfonic acid, its salts and related compounds (PFHxS)	Direct costs	Same assessment as for PFOA, its salts and related compounds.					
	Indirect costs						
Pentachlorophenol and its salts and esters (PCP)	Direct costs		No impacts envisaged		No costs or other adverse impacts envisaged.		No impacts envisaged.
	Indirect costs						
Dicofol	Direct costs	Given no waste streams containing dicofol have been identified in the EU no impact is expected from the introduction of limits in Annex IV and V. Consequently no direct or indirect costs are expected from the measure.					
	Indirect costs						

4. ANNEX IV: ANALYTICAL METHODS

4.1. INTRODUCTION

Annex IV values (also known as "low POP concentration limits" or LPCLs) are defined in Article 7(4)(b) of the POPs Regulation. They define the value for POP substances in waste at or above which they have to be destroyed or irreversibly transformed. In practice this means that below this value waste containing POPs can be treated by other means, including potentially be recycled.

Under the Stockholm Convention **a derogation** from the obligation to dispose of POPs in such a way that the POP content is destroyed or irreversibly transformed so that they do not exhibit the characteristics of POPs is provided under Article 6, paragraph 1 (d) (ii), for waste for which the "POP content is low".

These values are referred to as "low POP content limits" (LPCLs) in the "*General technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with persistent organic pollutants*"[11] developed and periodically revised under the Basel Convention. Table 2 of these, non-legally binding Guidelines contains a list of provisional definitions of "low POP content" for substances identified and listed as POPs under the Stockholm Convention. The Guideline also states that the "low POP content" described in the Stockholm Convention is independent from the provisions on hazardous waste under the Basel Convention.

Part 2 of Annex V of the POPs Regulation lists a number of **specific waste types** (many originating from thermal processes, such as ashes and slags) that **may be exempted** by Member States from being disposed of via a destructive treatment[12] **even if they exceed the Annex IV** value and up to the values in Annex V**.**

These listed wastes can rather be otherwise disposed of, using a method listed in part 2 of Annex V, which in practice means **permanent disposal in hazardous waste landfills or in underground storage facilities**.

Annex V values (also known as "maximum POP concentration limits" or MPCLs) are referred to in Article 7(4)(b) of the POPs Regulation and are also known as "maximum POP concentration limits" (MPCLs). They determine the **maximum concentration limit** in waste to which exemptions from destructive treatment apply for the aforementioned listed wastes. Furthermore, footnote 1 of the table in Part 2 of Annex V of the Regulation also specifies that, for wastes listed in part 2, disposal in a **permanent underground storage facility for hazardous waste** is still permitted, **even if the maximum value in Annex V is exceeded**.

Annex V values are **very rarely used** and have no influence on the possible recycling of waste. They only determine a very specific aspect of the final disposal of a limited list of waste types. Contrary to Annex IV values, Annex V values do **not have an equivalent in the Stockholm Convention** or in the technical guidelines developed under the **Basel Convention**.

The consequence of Annex IV and V limits is that for waste containing POPs in concentrations equal to or exceeding the Annex IV limit, only certain disposal or

[11] Currently under review. UNEP/CHW/POP-SIWG.4/3 (draft 28.10.2020). http://www.basel.int/Implementation/POPsWastes/Meetings/SIWGSwitzerland2020/tabid/8617/Default.aspx

[12] Treatments listed in Part 1 of Annex V the Regulation: D1: physical-chemical treatment; D10: incineration on land; R1: use principally as fuel or other means to generate energy, excluding waste containing PCBs; R4: Recycling / reclamation of metals / metal compounds (subject to conditions).

recovery operations (D9, D10, R1, R4) are permissible in accordance with Annexes I and II of Regulation 2008/98/EC.

Three concentration ranges (A, B and C), which are relevant under the POP Regulation, are generally possible for POP-containing waste. The consequences associated with different POP concentrations in waste depending on assigned Annex IV and V limit values are illustrated below.

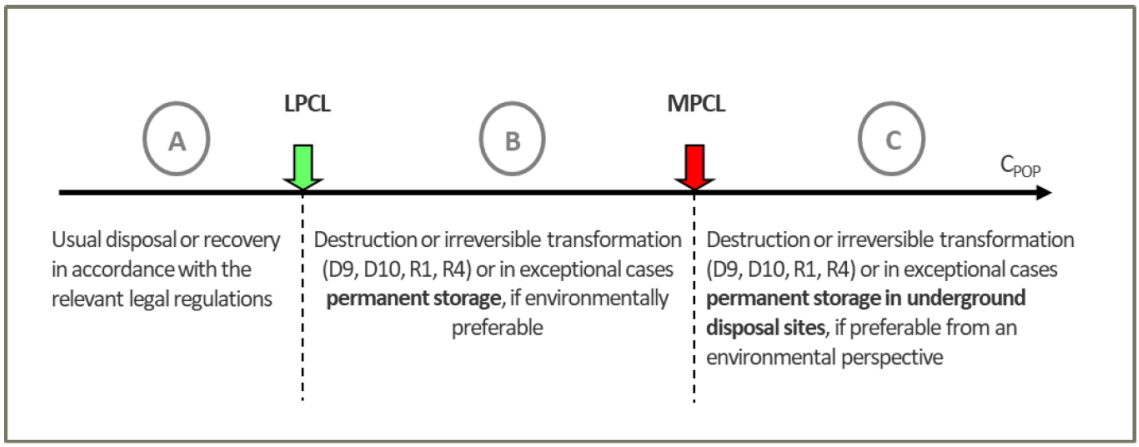


Figure IV-1 – Consequences of Annex IV (LPCL value) and Annex V (MPCL value) limit values in Regulation (EU) 2019/1021. Source – Ramboll (2019)

4.2. METHODOLOGY TO DERIVE ANNEX IV AND ANNEX V LIMIT VALUES

The referred General Technical Guidelines on POPs Waste briefly describe a methodology for deriving Low POP content limits. This methodology is described in a number of publications and was originally derived by BiPRO (currently Ramboll) in the year 2005 as part of work to derive such values, in the context of an amendment of the POP Regulation, at the request of the European Commission.

Concentration limits, or concentration limit ranges, for LPCLs and MPCLs used as a starting point for defining the options in this impact assessment were derived by Ramboll (2019)[13] using the referred methodology. The methodology uses a number of lower and upper limitation criteria to obtain a range for possible concentration limits. This approach enables on the one hand that the limit value can be implemented realistically in the light of the available data, and on the other hand, that human health and the environment are protected from POPs to a large extent. The further detail provided below is based, to a large extent, in the more extensive description of the methodology provided in ESWI (2011)[14] and Ramboll (2019).

Approach to propose Annex IV limit values

The basic principle of the method is based on establishing the **concentration range** for a possible limit value for each of the relevant substances by means of a set of different **lower and upper limitation criteria** which consider economic feasibility with regards to waste management, associated risks and analytical aspects to name but a few. These criteria indicate concentrations below which limit values should not be set (lower

[13] https://ec.europa.eu/environment/waste/pdf/Study_POPS_Waste_final.pdf
[14] Study on waste related issues of newly listed POPs and candidate POPs. ESWI Consortium (2011). https://ec.europa.eu/environment/waste/studies/pdf/POP_Waste_2010.pdf

limitation criteria) and the others indicate concentrations above which limit values should not be set (upper limitation criteria).

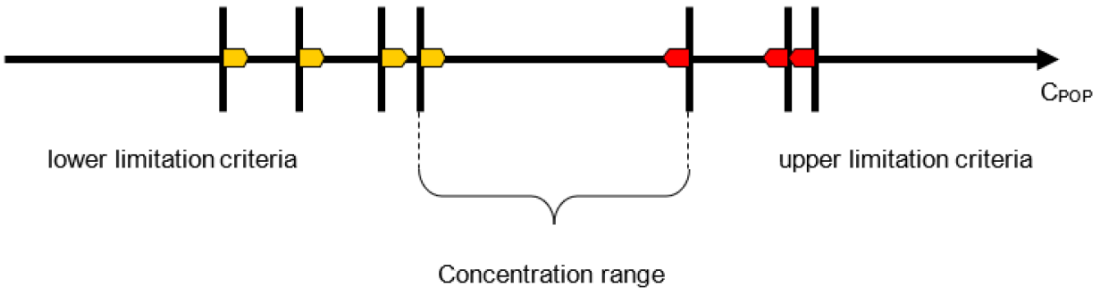


Figure IV-2 – Limitation criteria for the derivation of Annex IV. Source – Ramboll (2019)

To determine the range of possible limit values for every substance, **four lower and two upper limitation criteria** are applied (note several different values for the same limitation criterion can be depicted, e.g. different existing relevant legal limit values). Options can be derived from the aggregated analysis of the results for the individual criteria.

Lower limitation criteria:

(A) Analytical potential: *It must be possible to control limit values analytically*

From the economic and technical point of view the lower end of possible low POP concentration limits is marked by the limitations imposed to the system in terms of analytical accuracy and related costs. A limit which is not measurable in all Member States at reasonable economic conditions cannot be implemented. Thus laboratory capacity and the relation between detection limit and costs of different analytical methods is a major criterion for the finding of the lower boundary of low POP concentration limit options. Therefore, the limit (A) reported in the corresponding tables in Annex VI does not refer to the most sensitive quantification limit achievable, but rather to the values that can be determined in most service analytical laboratories, for the most unfavourable relevant waste matrices (these vary depending on the substance and rely on published analytical information and reports by laboratories). This is the reason why reported background values for some substances such as HBCDD, SCCPs or PFOA / PFHxS are lower than (A) values.

(B) Background contamination: *Limit values should be above existing environmental background contamination.*

The assessment of environmental levels should take into account the fact that the lower boundary for developing low POP concentration limits for POPs might be set by elevated POP concentrations in various environmental media. Any limit value should be significantly higher than average or background levels observed in the environment. A low POP concentration limit value below environmental background concentrations would cause severe economic problems and problems of acceptability if e.g. a soil with usual background concentration would have to be treated as POP waste as soon as it is excavated and the owner intends or has the obligation to discard it.

The monitoring results are divided in **typical background contamination** and elevated contamination, e.g. in the vicinity of point sources. In order to take into account the generally limited availability of data, an **uncertainty factor of 10** is applied and a corresponding value is derived, below which the Annex IV limit value should not be established.

(C or DR) Disposal and recovery capacities: *Limit values should be established in a way that the (new) required capacities for waste recovery and disposal are realistically available.*

Proposals for limit values should take into account that with a large number of waste types classified as POP wastes, considerable waste amounts might be directed to specific disposal/recovery operations. Therefore the proposals for a low POP concentration limit **should take into account whether sufficient disposal/recovery/recycling capacities exist** or can/must be established on national and community level for the management of the resulting POP waste streams. This assessment is supported by material flow analyses carried for this impact assessment.

(D or E) Economic feasibility*: costs to economic operators should not be disproportionate.*

Limit values should be established in a way that required additional waste management costs and other relevant economic impacts **can be reasonably borne by the economic operators** concerned. The evaluation of a possible low POP concentration limit against the economic feasibility depends on the induced POP waste quantities as well. Costs arise when material classified as POP waste requires specific treatment, or is excluded from profitable recovery operations.

Note: Reports from BiPRO/ESWI/Ramboll have used, throughout the years, different letters to refer to some of the different limitation criteria. To avoid confusion of the reader referring to the original reports, where different notations were used, both references are provided here.

Existing Annex I limits[15]: Under this criterion limits in Annex I of the POPs Regulation are taken into account. These establish "unintentional trace contaminant" levels for POPs present in substances, mixtures and articles placed on the market. It is **not considered proportionate** to establish stricter limits to regulate waste treatment than those associated to placing products on the market (usually mixtures or articles).

Upper limitation criteria:

(Z or LV) Existing limit values *agreed at Union level: Limit values should not conflict with existing limit values (e.g. by exceeding them).*

Proposed Annex IV limits should not exceed existing limits agreed at Union level. To define the upper limitation of the limit range, existing European legislation or international agreements in the field of waste management are taken into account. Stricter

[15] This element is not specifically defined as a limitation criterion under the methodology initially developed by BiPRO (2005), probably because at the time no such values had been introduced in Annex I, but is referred to in ESWI (2011), pg. 637, where it is stated that "*assessment also includes the proposed threshold below which a substance is considered to be occurring as an unintentional trace contaminant*". In the application of the methodology, as used in this impact assessment, the UTC limit, where available, is used a lower limitation criterion.

regulation in single Member States must not pose a constraint for the upper limitation of the range of possible options for concentration limits. This analysis is supported by examining relevant EU and Member State legislation, as well as international agreements on waste.

***(Y or R) Risks** (possible adverse effects on human health and the environment):*

Limit values should be established in a way that **adverse effects on human health and the environment are avoided** and human health and the environment are protected from persistent organic pollutants as far as possible.

As described in Ramboll (2019) this criterion targets the following risk components: the possible events of damage that can occur along the life cycle of a waste, their severity, and the realistic probability of such an event. Consequently, the assessment methodology with respect to criterion Y/R combines elements of Life Cycle Assessment, conventional risk assessment and impact assessment.

The potential impacts from waste disposal/recovery on environment and humans have been assessed in Ramboll (2019) and, for some substances relevant elements can also be found in ESWI (2011) and BiPRO (2005). Relevant toxicological reference values relevant to human health and / or to receptors in the environment, for the substances concerned, were retrieved from the literature and analysed: [Predicted No-Effect Concentrations (PNECs), existing environmental quality standards (EQS) and, for some substances, Tolerable Daily Intake values (TDIs), Maximum Residue Levels (MRLs)] and published risk assessments.

For POP substances in waste streams where a foreseeable treatment includes application on land (particularly R10 "land treatment resulting in benefit to agriculture or ecological improvement") the applicable health based limitation criterion is directly based on the relevant toxicological benchmark value for the substance (e.g the PNEC). For POP substances in waste where **spreading on land is not a relevant treatment operation**, the health based limit value proposed takes into account the estimated reduction in the concentration of POPs reaching the environment that results from waste being disposed in a non-hazardous waste landfill (this being the most likely, non-destructive alternative for most waste streams in the study).

As described in Ramboll (2019) the health-based benchmark value in such cases is calculated based on a dilution factor of 10,000 (0.0001) which is applied[16] to the lowest toxicological benchmark value (usually the PNEC value for soil or sediment organisms) identified in literature, and used to back-calculate a maximum concentration in waste.

A summary of the health based values used and considerations of how this approach has been applied for each substance is provided in section 4.3 below. Further detail is provided in the supporting studies by Ramboll (2019)[17] and ESWI (2011)[18]. It should be noted that these values are based on estimations and assumptions and therefore uncertainties exist in all values. A full risk assessment for all substances considered,

[16] Studies on the leaching rates on non-stabilised and stabilised POP waste quoted in ESWI 2011 (pg 733) indicating values between 10^{-5} and 10^{-6} and a factor 100,000 is used for hazardous waste landfills. Given the less stringent containment measures required for non-hazardous waste landfills a conservative dilution factor of 10^{-4} is applied in the supporting study by Ramboll (2019) to this report.

[17] See pages 233 – 240 of the Ramboll report.

[18] See pages 647 – 649 and 695 – 706 of the ESWI (2011) report

covering all possible waste treatments and exposure routes, was out of the scope of the supporting studies.

The protection of the health of workers, including in waste management installations, is addressed by Directive 89/391/EEC on the introduction of measures to encourage improvements in the safety and health of workers at work. This Directive requires, among other things, that employers "*take the measures necessary for the safety and health protection of workers, including prevention of occupational risks and provision of information and training, as well as provision of the necessary organization and means*". It also requires employers to evaluate the risks to the safety and health of workers and implement the necessary preventive measures. Provisions to protect the health of workers from risk arising from exposure to chemicals in the workplace are further developed under the **Chemical Agents Directive**[19] and the **Carcinogens and Mutagens Directive**[20].

Carrying out a risk assessment relative to the health of workers, relative to the different treatment operations, posts of work, waste types and substances covered in this impact assessment is beyond the scope of the supporting studies which are the basis of this impact assessment and have not been addressed (given this matter is addressed by other Union legislation). However, all proposals leading to a lowering of the concentration of POPs in waste can **potentially result in a lower exposure of workers** involved in the final stages of recycling operations, or to a reduced need to apply collective of personal preventive measures. This is not the case in other waste management operations, involving pre-treatment and disposal of POP waste, where waste above Annex IV (and sometimes Annex V) limits has to be handled.

Taking due account of this the methodology incorporates the **precautionary principle** by requiring the additional application of a "target function II" which has the effect of lowering the proposed Annex IV limit value, even if the health based limit value would be higher.

The methodology applies two **"target functions".** According to these, a resulting range is reduced to a specific POP concentration limit.

The resulting range of feasible and implementable limit values differs for different POPs and different results can be expected for different waste types. Thus it will not be possible to derive specific proposals for limit values and it is therefore necessary to reduce the range of possible options for a limit value to an implementable proposal for one specific value. For this purpose the methodology foresees the use of **target functions** as standard decision tool in decision theory in order to reduce the range of potential options.

The following target functions are applied:

Target function I: "Reduce results for different waste matrices to the most unfavourable waste matrix" can be applied to Criterion A (analytical potential) in order to reduce the large variety of achievable limits of quantification to an implementable value for all relevant waste matrices.

[19] Directive 98/24/EC on the protection of the health and safety of workers from the risks related to chemical agents at work. OJ L 131, 5.5.1998, p. 11.

[20] Directive 2004/37/EC on the protection of workers from the risks related to exposure to carcinogens or mutagens at work. OJ L 158 30.04.2004, p. 50.

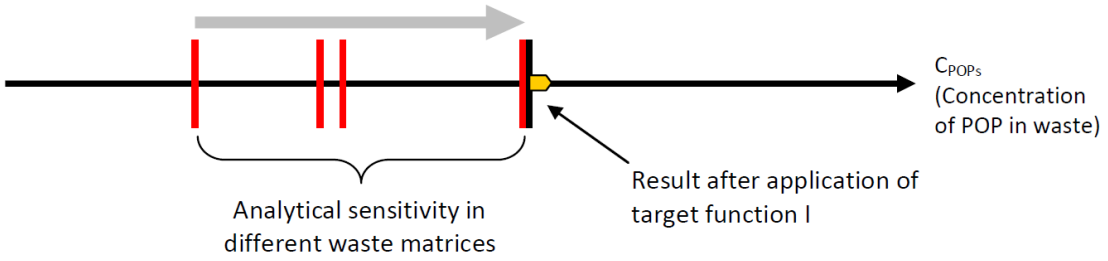


Figure IV-3 – Target function I. Source – ESWI (2011)

Target function II: "Reduce the limit value to the lowest limit value within the feasible and implementable range of options" in the final decision on an Annex IV limit proposal within the range defined by upper and lower limitation criteria. This target function is also referred to as "criterion X" in Ramboll / ESWI reports done for the Commission prior to 2019.

This contributes to implementing the "precautionary principle" as used under the Stockholm Convention (Articles 5-7) "*Each party shall …take …measures to reduce the total releases…with the goal of their continuing minimization and, where feasible, ultimate elimination*".

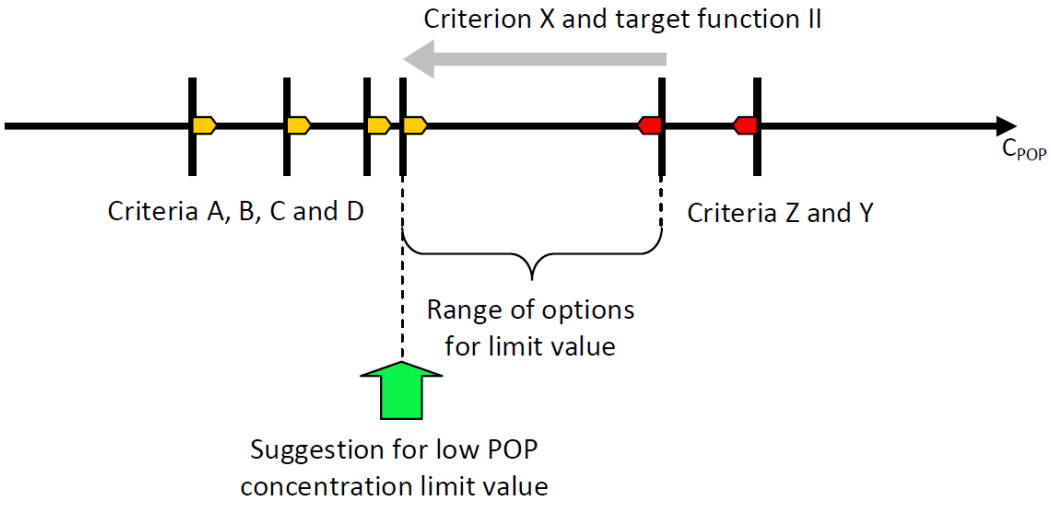


Figure IV-4 – Target function II. Source – ESWI (2011)

Finally, the application of lower and upper limitation criteria **may result in controversial and contradictory requirements for limit values**, as illustrated in the figure below (at least for wastes subject to specific treatment / disposal methods). In such cases there is a contradiction between the results of the criteria because lower limitation criteria result in limit values above upper limitation criteria.

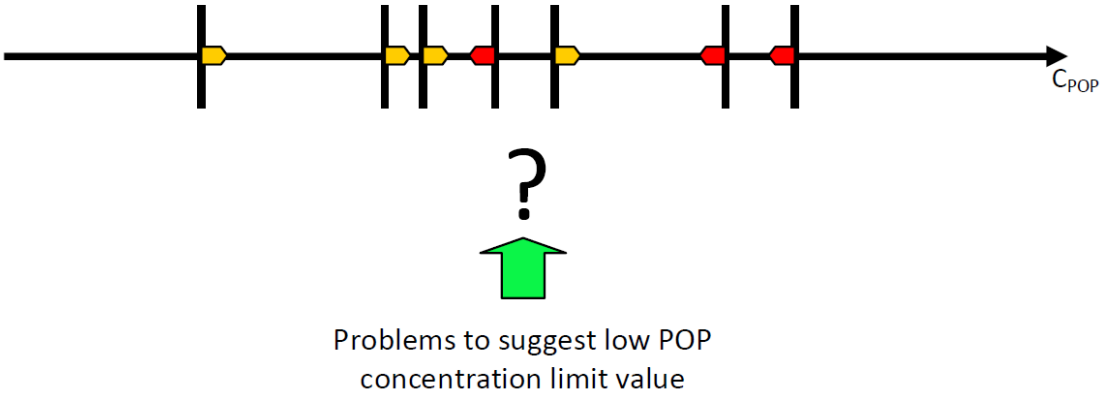


Figure IV-5 – Contradictions in the application of limitation criteria. Source – ESWI (2011)

As a consequence no range of possible options to set limit values results from applying the method. In such cases, **expert discussion** is necessary and additional requirements (for example via policy choices) have to be established to resolve the contradiction. In this respect see section 4.3 below on PCDD/Fs).

Calculation of Annex V limit values

When proposing an Annex V value the **lower limitation criterion** is in practice reduced to one: it **cannot be lower than the Annex IV value**. This is imposed by the logic of the POPs Regulation, whereby, according to Article 7(4)(b), the Annex V value provides a ceiling to the possibility to derogate from the obligations imposed under Article 7(4)(a) for wastes that exceed the Annex IV value.

In practice the Annex V value is determined based on a single upper limitation criterion, representing the estimated POP concentration above which **risks occur in a worst case scenario** to humans or the environment, not allowing the application of an environmental preferable solution other than destruction or irreversible transformation. Such scenarios refer only to disposal of the waste in a **hazardous waste landfill or to permanent disposal in an underground storage facility** (given these are the only options permitted for wastes listed in Part 2 of Annex V of the Regulation when their POP concentration is above the Annex IV value).

The health based reference values that support the proposal of Annex V limit values were calculated by ESWI (2011) and Ramboll (2019) using **two approaches**[21] which take into account two ways of estimating the leaching and release of relevant POP substances (and their resulting corresponding concentrations in the receiving environment), when POP waste above Annex IV values is disposed in a **hazardous waste landfill** (instead of being destroyed).

The **first approach** is based on leaching rates of certain POPs in hazardous waste landfills (estimated 0.00001) and an estimation of the efficiency of advanced waste water treatment plants treating such leachate (estimate to be 0.005). Under the assumption that the concentration of the leachate released **must not exceed the environmental quality standard** (EQS) for inland waters as published in Directive 2008/105/EC (or in their

[21] See pages 729 – 739 of ESWI (2011)

absence other limit values relevant to surface waters), these values are back-calculated to a maximum concentration in waste.

The **second approach** uses an assumed worst case dilution factor in the landfill, based on leaching tests for PCDD/Fs, of 1/100,000 and uses published **background levels** for the relevant POP substances in soil, to back-calculate possible maximum concentration values in waste.

As noted for Annex IV health-based values, estimations provided by these methods are approximations based on assumptions on the behaviour of POPs in landfills. They are not the result of specific modelling or hydrogeological studies, which are beyond the scope of the supporting studies carried-out.

The methodology under the Basel Guidance

A description of the methodology, as taken up in a summarised form in non-binding information documents developed under the Basel Convention, can also be found in the Annex of the document UNEP/CHW/OEWG.9/INF/9/Add.1[22]. A transcript of this description is provided below:

The following set of considerations can be used to determine the concentration levels to define the low POP content for each new POPs listed in Annex A, B, and C. In some cases, provisional definitions of low POP content may be applicable to the new POPs in the same chemical category. The considerations are as follows:

Analytical potential: Concentration at which the POP can be detected and quantified. The analytical accuracy, which involves the laboratory capacity, availability of analytical methods and cost of detection must be factored in the selection of a low POP content. The ability to measure concentration in different types of materials and matrices is essential in determining if certain waste streams are above or below the low POP content level and if measures can be implemented and enforced effectively;

Environmental background contamination: Average concentration of the POP found in the environment due to anthropogenic interference. Estimation of the environmental background contamination and how each POP chemical has spread in the global environment is a complex undertaking. International monitoring data for soil, sediment, biota, water and atmosphere provides an indication upon which an average level concentration can be set;

Potential health impacts: Risks to human health associated with exposure to POP from waste streams are observed. Taking into account scientific assessments (risk profile and risk management evaluations) of POPs under the Stockholm Convention, the potential health impacts should be considered when defining the low POP content level for each chemical;

Potential environmental impact: Risks to the environment associated with releases from POP waste streams are observed. Taking into account scientific assessments (risk profile and risk management evaluations) of POPs under the Stockholm Convention, the potential environmental impacts should be considered when defining the low POP content level for each chemical;

Disposal capacity: Available disposal capacity to manage in an environmentally sound manner the POP wastes above the low POP content definition. The availability of facilities capable of destroying and/or irreversibly transforming POP wastes above the low POP content level is relevant for its successful implementation;

Economic considerations: Economic feasibility to manage in an environmentally sound manner the POP wastes above the low POP content level. Economic considerations including other societal implications associated with the environmentally sound management and destruction of POP wastes above the low POP content level should be considered when defining the low POP content level for each chemical.

22 http://www.basel.int/TheConvention/OpenendedWorkingGroup(OEWG)/Meetings/OEWG9/MeetingDocuments/tabid/3684/Default.aspx

In addition to the factors listed above, other considerations should be kept in mind in determining low POP content such as:

1. All considerations may not be equally important to define the low POP content level;
2. The total volume of waste and the total concentration of POP captured will vary depending on the low POP content level (e.g. the lower the established low POP content level, the greater the volume of waste captured);
3. Various POP waste streams are not equal in terms of health and environmental impacts;
4. A precautionary approach should be taken to manage wastes with high impacts (either on human health or the environment) and high volume waste streams with unique characteristics;
5. The uncertainty and lack of knowledge and data may influence the establishment of the low POP content.

4.3. HUMAN / ENVIRONMENTAL HEALTH VALUES FOR ANNEX IV AND V

As indicated in the previous section, different health based values can be calculated for different waste treatments. For those that imply direct application of waste onto soil, particularly the application of **sludge for agricultural purposes**, toxicological reference values such as the PNEC for soil / sediment, or their legal limit-value equivalent expressed as environmental quality standards (EQS), are used as an estimation of values considered protective. For POP wastes for which typical concentrations of relevant POPs in sludge are below relevant published toxicological reference values, or for which no relevant application on land takes place in the EU, no further consideration is given to proposing a health based limit based on a land application scenario.

An analysis of typical concentrations of relevant POPs in sludge, as comparted with PNEC values for soils and sediments, reproduced below, is provided in Table 69 of Ramboll (2019).

Substance/ Substance groups	(P)NEC values for soils and sediments [mg/kg]	Typical contents in sewage sludge [mg/kg]
decaBDE	Soil: ≥98 mg/kg Sediment: ≥384 mg/kg dry	248 ug/kg dw UNEP/POPS/POPRC9 SUBM BDE Denmark 1 2014 as cited [Christensen et al. 2003]
SCCP [Bogdal et al. 2015]	Soil: 5.95 mg/kg (wet)	0.135 and 0.584 mg/kg dry weight (dw)
HCBD [BIPRO 2015]	Sediment: 24,4 µg/kg	~ 6 µg/kg 39-597 µg/kg [JRC 2012]
Dicofol	Sediment: 0.0237 µg/l	Insufficient data
PFOA	Insufficient data	0.011-0.018 [JRC 2012]
PFHxS	Insufficient data	Insufficient data
HBCDD [BIPRO 2015]	0.17 - 5.9 mg/kg	~ 60 µg/kg

Table IV-1 – PNEC values and typical concentrations in sewage sludge. Source – Ramboll (2019)

In addition UBA (2015) reports, in its table 92, a PNEC for Pentachlorophenol of 12.4 – 124 µg/kg and typical concentrations of PCP in sewage sludge of approximately 20

µg/kg. As regards decaBDE, ECHA (2015)[23] further indicates that generally the decaBDE concentration in sewage sludge in the EU is around 0.1 mg/kg dry weight up to a few mg/kg dry weight.

These figures indicate that in general values in sludge are below the proposed existing toxicological thresholds and therefore, are not considered further here.

An assessment of relevant **organic substances in sewage sludge**, including POPs, is currently underway in a dedicated study in support of the evaluation of the Sewage Sludge Directive. If following the prioritisation and assessment being carried out, the setting of specific limits associated to protection of human health or the environment were to be considered appropriate, these **would be set in the context of the review of the Directive 86/278//EEC**[24] (given this is the specific instrument for this specific waste recovery operation under EU legislation).

The possibility of using a health-based value for PCDD/Fs and dioxin-like PCBs, based on a land-disposal scenario is discussed specifically further below, given their possible presence in relevant concentrations in certain ashes used in agriculture (e.g. biomass ashes) and, potentially in a certain fraction of sewage sludge generated.

Based on the above, and as further explained below for PCDD/Fs (and dl-PCBs), health based limit values used as criterion R (or Y) when applying the methodology, do not take into account direct land application of waste, given such specific concerns either do not seem to apply or, in the case of PCDD/Fs in sludge / ashes are **best addressed via dedicated existing EU and national legislation**. Consequently health based limits proposed and used in this impact assessment relate to estimations of impact associated to waste being disposed in a non-hazardous waste landfill (associated to Annex IV limits) and to a hazardous waste landfill (Annex V limits).

Considerations regarding landfill disposal

Annex I to Directive 1999/31/EC defines general **design and performance requirements for landfills** in the EU. A landfill must be situated and designed so as to meet the necessary conditions for preventing pollution of the soil, groundwater or surface water and ensuring efficient collection of leachate as and when required according to Section 2 of the referred annex. Protection of soil, groundwater and surface water is to be achieved by the combination of a geological barrier and a bottom liner during the operational/active phase and by the combination of a geological barrier and a top liner during the passive phase/post closure.

The geological barrier for **hazardous waste landfills** has to fulfil the following permeability and thickness requirements: $K \leq 1{,}0 \times 10^{-9}$ m/s; thickness ≥ 5 m. In addition to the geological barrier a leachate collection and sealing system consisting of artificial sealing liner and drainage layer ≥ 0.5 m is required so as to ensure that leachate accumulation at the base of the landfill is kept to a minimum.

For **non-hazardous waste landfills** the requirements for the geological barrier are: permeability $\leq 1{,}0 \times 10^{-9}$ m/s; thickness ≥ 1 m. Permeability requirements for **inert waste** landfills are considerably less stringent but waste containing POPs should, in

[23] Background document to ECHA opinion supporting the DecaBDE restriction under REACH. Restriction (page 38). https://echa.europa.eu/documents/10162/9fa186cb-63d8-8276-eb13-36ef6f8c1e89

[24] See: Sewage sludge use in farming – evaluation (europa.eu)

principle, not be disposed in such landfills given it is unlikely such waste would comply with the definition of "inert waste" in Article 2(e) of the Landfill Directive.

Article 6(a) of the Directive requires that **only waste that has been subject to treatment is landfilled** unless such treatment is not technically feasible or such treatment does not contribute to the objectives of this Directive by reducing the quantity of the waste or the hazards to human health or the environment.

Considering that waste containing POP substances disposed of in landfills in the EU will be subjected to measures that **significantly reduce their release** to the environment (via stabilisation treatments and/or limitations of emissions due to containment measures), this has been taken into account when estimating the proposed health based values for this treatment which is considered, in practice a (rough) benchmark for determining Annex IV and V values.

Health risk values for Annex IV

The following table contains a summary of toxicological reference values (PNECs for soil / sediment organisms) and their translation into a health-based reference value, as described in section 4.2. above, for the purposes of applying the methodology to propose an Annex IV value. This value, where its calculation has been possible, is referred to in the summary table and in the lower and upper limitation criteria diagrams provided for each substance in Annex VI of this report.

These values are derived mostly from Ramboll (2019)[25] and, where appropriate, complemented by other sources.

Substance	PNEC/ EQS for soil / sediment	Calculated health based value (R/Y)	Comment
PBDEs (decaBDE)	98 mg/kg	980,000 mg/kg (≈ 1,000,000 mg/kg)	The value resulting from this estimation is not considered further in view of the impossibility[26] of applying a standard risk assessment approach, based on a PNEC, to decaBDE. This is in line with Ramboll (2019) where a health-based value is ultimately not proposed.
HBCDD	0.17 mg/kg	1,700 mg/kg (≈ 1,000 mg/kg)	Rounded to 1,000 mg/kg (criterion Z, existing limit value). The PNEC value of 0.17 mg/kg is broadly consistent with the "concentration of concern" of 1.6 mg/kg (dry weight) for benthic organisms (*L. variegatus*) reported in a recent review on HBCDD by USEPA[27].
SCCP	1,76 mg/kg	17,600 mg/kg (≈ 18,000 mg/kg)	-
PFOA and compounds	Insufficient data	-	No reliable criterion for soil / sediment could be derived. For environmental exposure the ECHA assessment for PFOA, in the context of the restriction applies the PBT approach which relies on the

[25] See table 70 in Ramboll (2019)

[26] "No PNECs or DNELs have been calculated, as the risks of PBT/vPvB substances cannot, in general, be assessed quantitatively". Background document to the Opinion on the Annex XV dossier proposing restrictions on Bis(pentabromophenyl) ether. ECHA 2015.

[27] Risk Evaluation for Cyclic Aliphatic Bromide Cluster (HBCD). USEPA 2020. https://www.epa.gov/assessing-and-managing-chemicals-under-tsca/final-risk-evaluation-cyclic-aliphatic-bromide-cluster#documents

			minimisation of emissions. In a recent PFAS National Environmental Management Plan[28] by Australia, landfill admission criteria for waste containing PFOS, PFAS and PFHxS are proposed, with an interim value of 50 mg/Kg (value for PFAS).
PFHxS and compounds	Insufficient data	-	See above. Australia proposes an interim value for landfill admission of 50 mg/kg for the sum of PFOS and PFHxS.
PCP	12,4 µg/kg	124 mg/kg (≈ 100 mg/kg)	UBA (2015) based on lowest end of the range of PNEC values for soil and sediment. An earlier proposed value of 5,000 mg/kg (ESWI,2011) based on a US ATSDR maximum residue limit screening value is not used for consistency in the approach and because the approach chosen results in a more stringent value.
Dicofol	0.0237 µg/L	237 mg/kg (≈ 200 mg/kg)	Based on EQS for sediment. Value rounded to 200 mg/kg,

Table IV-2 – Calculated health-based criteria for Annex IV limit value calculations. Based on Ramboll (2019) and adapted.

Health risk values for PCDD/Fs and dl-PCBs

The approach used for PCDD/Fs and related dl-PCBs is different to what has been described above, given the critical effect identified results from **potential food-chain exposure of humans**, in a scenario where **ashes or sludge are applied on land** (mostly for agricultural purposes). The calculation of health based limit values for this waste management option rely on estimated transfers of PCDD/Fs from waste to soil and its uptake into the food chain, and ultimately to humans, via **eggs from exposed hens** (which feed on produce grown on contaminated soil or are directly exposed to it). Maximum "critical values" in soil can be back-calculated from human-health based limits for dioxins in eggs. Currently the maximum values in hen's eggs defined in Regulation (EC) 1881/2006 setting maximum levels for certain contaminants in foodstuffs are of 0.0025 and 0.005 µg WHO TEQ/kg fat, for PCDD/Fs and for PCDD/F + dl-PCBs, respectively.

BiPRO (2005) estimated, only for PCDD/Fs, that the maximum concentration in soil (and by rough approximation also for waste applied to soil) that could be allowed so as to meet health-based limits for human exposure to PCDD/Fs via consumption of eggs, was of 1 µg/kg (0.001 mg/kg). As reported in Ramboll (2019) later assessments carried out by the Swedish EPA and in particular by IPEN/Arnika seem to indicate that the transfer from soil to eggs could have been underestimated in the 2005 report and a critical value in soil (and waste) **of 0.05 µg WHO TEQ/kg is proposed for PCDD/Fs**, which would be of 0.1 µg/kg for the sum of PCDD/Fs and dl-PCBs (0.00005 or 0.0001 mg WHO TEQ/kg, respectively).

Such proposed health-based limits for direct application of untreated waste on soil are **broadly consistent with existing or proposed limits in specific EU / national legislation** (non-exhaustive list):

[28] PFAS National Environmental Management Plan Version 2.0. Heads of EPA Australia and New Zealand 2020. PFAS National Environmental Management Plan 2.0 | Department of Agriculture, Water and the Environment

- Draft Commission Delegated Regulation amending Annexes II, III and IV to Regulation (EU) No 2019/1009 of the European Parliament and of the Council for the purpose of adding **thermal oxidation materials and derivates** as a component material category in EU fertilising products[29]. Here a limit value for PCDD/F of 20 ng WHO TEQ/ Kg dry matter, that is 0.00002 mg WHO TEQ/kg that applies to ashes that can be introduced in CE-labelled fertilisers. The Commission adopted this measure on 6 July 2021.
- Austrian limit for PCDD/Fs in biomass ashes[30] used in agriculture and forestry: 0.00002 mg WHO TEQ/kg (dry mass).
- Austrian Fertiliser Act. Absolute limit for PCDD/Fs of 0.00005 mg TEQ/kg dry matter for the use of ashes as raw materials for fertiliser.
- The German Sewage Sludge Ordinance, sewage sludge, that will be applied on land for agricultural purposes, must be tested for PCDD/F and PCB. The limit values established under the German Fertiliser Ordinance must not be exceeded (sum of dioxins and dl-PCBs 30 ng TEQ; 8 ng TEQ when applied on grassland for fodder production and on arable forage land with non-rotational tillage after application).
- Italy has provisions[31] establishing limits for PCDD/Fs and dl-PCBs in sewage sludge used in agriculture, with a limit of 0.000025 mg WHO TEQ/kg /dry matter).
- Portuguese Decree on Fertilisers[32] establishes a limit of 0.0001 mg TEQ / kg dry matter in fertilisers that include urban sewage sludge as a component material.

Consequently a health based limit value of between 0.00002 and 0.0001 mg WHO TEQ/kg, associated to concentrations in soil to prevent significant food chain contamination seems supported by current proposals / legislation at EU and Member State level. For the purpose of this impact assessment a health based value (R/Y value) of **0.00005 mg WHO TEQ /kg (50 ng/kg dry matter) for PCDD/Fs + dl-PCBs in untreated waste applied on land for agricultural purposes is considered**.

As indicated above, for PCDD/Fs + dl-PCBs, **limits for land treatment are not proposed** as the relevant health-based (R/Y) criterion when applying the methodology for proposing an amendment to the Annex IV value in the POPs Regulation given that:

a) such low limits would seriously limit the possibility to dispose ashes and of other relevant waste streams in non-hazardous waste landfills;

b) specific legislation exists at EU and national level for this type of application on land;

c) limit values for organic substances, including potentially PCDD/Fs are currently being considered in the evaluation of the Sewage Sludge Directive;

d) other potentially soil contaminating uses such as spreading of MSWI ashes in soil for agricultural purposes or as a consequence of mis-

[29] https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12162-Thermal-oxidation-materials-and-derivates-in-EU-fertilising-products

[30] https://bfw.ac.at/050/pdf/Richtlinie_Pflanzenasche-120417.pdf

[31] Decreto-Legge 28 settembre 2018, n. 109

[32] Decreto-Lei n.º 103/2015

management, or its use as poultry litter, is not reported to be a relevant practice in the EU (see Ramboll 2019).

In order to determine a **generally applicable health-based limit value estimate**, BiPRO (2005), analysed the scenario of what was considered the next critical disposal / recovery operation of PCDD/F - containing waste (especially fly-ashes) and determined this to be **use in construction**.

According to Dutch research on the life-cycle analysis of fly-ash used as filler in asphalt for construction[33], quoted in BiPRO (2005), it was concluded that leaching from the material will be of the order of 0.001% over 100 years. This corresponds to an annual dilution factor of 10^{-7}. Using a worst case approach the leaching has been fixed at 1% over 100 years corresponding to leaching estimates for media with high organic and detergent concentration (i.e. a dilution of 10^{-4} is considered). Under such scenario, which considers the current legal limit of 15 µg/kg, a maximum of 0.0015 µg/kg PCDD/F (0.0000015 mg/kg) from processed fly ash can be assumed to be discharged annually to the environment by leaching effects associated to that use. Based on such estimations, although with some uncertainty, the existing Annex IV limit for PCDD/Fs of 0.015 mg/kg WHO TEQ was **not considered likely to cause risks** to health and environment.

There is a limited number of published reference values for PCDD/Fs applicable to soil / sediments, given TEF toxicity equivalence values are relevant in terms of human intake and therefore not directly applicable to environmental risk assessment (e.g. for soil or water organisms). By way of reference the Dutch maximum value for dioxins in land for residential use[34] (which takes into account human health and environmental protection) is fixed for dioxins in soil at **0.000055 mg TEQ/Kg** (dry matter). This value is over one order of magnitude greater than the estimated concentrations resulting from releases from (stabilised) construction material. The latter are also considered representative to concentrations in soil that could result from of releases from waste disposed in a non-hazardous waste landfill.

Consequently the **general health-based reference value** used in this impact assessment for waste containing PCDD/Fs is the current legal limit of 0.015 mg/kg.

Health based risk values for Annex V

Data sources for Approach 1 can be found in Table 68 of Ramboll (2019), except for PCP. Data sources for Approach 2 can be found in Table 78 in section 10.5 of the annex of Ramboll (2019).

Substance	Approach 1	Approach 2	Comment
decaBDE	-	2,7 – 110 mg/kg (3) 165,000 mg/kg (4)	(1) By way of reference approach 1 using the value of 0.14 µg/L (MAC-EQS) established for PBDE congeners listed the EQS Directive (2008/105/EC) amending the Water Framework Directive, which does not include decaBDE, would result in a value of 2,800 mg/kg).
PBDEs	2,800 mg/kg (1) 10,000 mg/kg (2)	6 – 1,200 mg/kg (5)	(2) Austrian emission limit quoted for PentaBDE in

[33] Environmental impact Report – National Waste Management Plans; LCA-AVI-vliegas, final report, TAUW Netherlands, 2002.

[34] See Swartjes et al. 2012. (extra content SD3 associated to the article). https://www.sciencedirect.com/science/article/pii/S0048969712003294?via%3Dihub

			ESWI (2011), table 9-50. For approach 2, a values of: (3) 0.027-1.1 µg/kg as lowest range of background measurements for Sweden are used and recalculated from Ramboll 2019. (4) If the typical background value for Sweden of 1,650 µg/kg is used as reported by Ramboll (2019) (pg 2016 of the report). (5) ESWI (2011) quotes lowest range background concentrations for PBDEs of 0.06 -12 µg/kg.(see page 735).
PFOA and compounds	2,000 mg/Kg	6,1 – 68 mg/kg	Approach 1 – Based on RIVM EQS of 2017 of 0.1 µg/L For Approach 2, background values quoted for Europe have been used (0.061 – 0.684 µg/kg for sediment) and re-calculated from Ramboll 2019.
PFHxS and compounds	2,000 mg/kg	20 – 63 mg/kg	Approach 1 – Based on EQS by LAWA (DE) of 2017 of 0.1 µg/L For Approach 2, background values quoted for France have been used (<0.2-0.63 µg/kg for sediment) and re-calculated from Ramboll 2019.
PCP	8,000 mg/kg	10,000 mg/kg	For Approach 1 UBA(2015) proposed an EQS range of 0.2 – 2 µg/l based on EuroChlor 1999. For the current estimation the AA-EQS of 0.4 µg/L under Directive 2008/105/EC has been used. For approach 2 UBA(2015), based on ESWI(2011) reports background concentrations of PCP in Germany of 42 µg/kg in sediment and provides a range for Europe, in soil, of 0.5 – 4000 µg/kg. An average value of 0.1 mg/kg has been used.
Dicofol	26 mg/kg – 200 mg/kg	3,600 mg/kg	Approach 1 based on AA-EQS of 0.0013 µg/L under Directive 2008/105/EC and on the value by the International Office for Water and INERIS.

Table IV-3 – Calculated health-based criteria for Annex V limit value calculations. Based on UBA (2015) and Ramboll (2019) and adapted.

In its conclusions on health based reference values for the determination of the Annex V value, Ramboll (2019) acknowledges the many uncertainties associated to the approach used (which is reflected in the high dispersion of possible values). Therefore these values are used for orientation in the methodology but a greater weight is given in this case to criterion Z (existing limit values) for the same or similar substances, which reflects previous political agreement on values for the substance, or for substances with similar toxicity.

4.4. QUANTIFICATION OF IMPACTS

The analysis carried out in this impact assessment focuses on determining, to the extent possible, the following environmental, social and economic impacts associated to the different options, for each of the substances and related waste streams:

- Changes in the mass flows of POPs – how much is removed / destroyed?
- Estimated health and environmental benefits associated to the reduction in the releases of POPs from waste or from recovered materials (eg in terms of reduced

healthcare costs incurred). Impacts on worker's health and on the general population (consumers).

- Effectiveness of the measure. How do emission reductions projected compare to other existing emissions / sources of exposure? To what extent does the measure contribute to addressing the problem of exposure to the relevant POPs? Would other measures / instruments be better suited?

- Changes in the amounts of waste sent to different treatment options (recycling, incineration, landfill, etc).

- Costs and benefits for waste producers and waste operators (especially for SMEs) resulting from the different treatment outcomes. This includes investment costs in equipment and well as additional monitoring / operational costs (eg. analytical costs). Impacts on employment.

- Changes brought about in the availability / implementation of technologies – eg. waste sorting and decontamination technologies.

- Administrative burden for both operators and public administrations. Need for additional controls, differences on permitting, administrative costs, enforcement costs.

- Indirect impacts brought about by changes in limit values – differences in national / regional implementation of rules on waste classification (hazardous – non-hazardous) and on waste shipments. Impact on customer perception and behaviour to recycled material.

- Changes in the amount of available secondary material resulting from recycling. Impacts on supply and quality of secondary materials including impact on users of secondary material. Impact on competitiveness and trade.

- Changes in greenhouse gas emissions associated to the different options.

The information obtained and presented relies on the **extensive desk research** carried out by external consultants in the two studies which support this impact assessment [Ramboll (2019)[35] and RPA(2021)[36]]. An understanding of the waste streams relevant for each substance and the **mass flows of each waste and POP substance concerned** have been developed and presented in these studies based on literature research and stakeholder consultation, the latter based on questionnaires and interviews. Assumptions and uncertainties underpinning the estimated mass flows as well as on the impact estimations made, for instance on waste treatment outcomes and how they will evolve in the coming years, are provided in the relevant substance chapters of the referred studies.

For some of the substances **projections on how the concentrations in waste will evolve over time, and of waste amounts**, have been made based on the analysis of existing trends (as in the case of PBDEs in WEEE and ELV plastic waste, SCCPs in rubber and PCP in wood waste). These estimations are also supported by assumptions that patterns in waste generation will follow the same trend as production / use statistics for the

[35] https://ec.europa.eu/environment/waste/pdf/Study_POPS_Waste_final.pdf

[36] Study to support the assessment of impacts associated with the review of limit values in waste for POPs listed in Annexes IV and V of Regulation (EU) 2019/1021. European Union 2021. ISBN 978-92-76-41943-3.

substance in Europe, taking into account the delay in the material becoming waste. This is linked to the lifetime of the different applications (i.e. service life of construction products in a building, of a car, o electronic equipment).

5. ANNEX V: LEGISLATION RELEVANT TO POPS

5.1. INTERNATIONAL AGREEMENTS

5.1.1. The UNECE Protocol on POPs

The Executive Body to the UNECE Convention on Long-Range Transboundary Air Pollution (CLRTAP) adopted the UNECE Protocol on POPs on 24 June 1998 in Aarhus, Denmark. The UNECE Protocol on POPs focuses currently on a list of 26 substances comprising 13 pesticides, 10 industrial chemicals and three unintentional by-products. The ultimate objective is to **eliminate any discharges, emissions and losses of these POP** substances.

The UNECE Protocol on POPs bans the manufacture and use of some substances outright (aldrin, chlordane, chlordecone, dieldrin, endrin, hexabromobiphenyl, hexachlorobutadiene, hexachlorocyclohexane (technical HCH), hexaBDE, heptaBDE, tetraBDE, pentaBDE, pentachlorobenzene, polychlorinated napthalene (PCN), mirex and toxaphene). Others are scheduled for elimination at a later stage (dichloro-diphenyl-trichloroethane (DDT), heptachlor, hexachlorobenzene (HCB), polychlorinated biphenyls (PCBs), perfluorooctane sulfonate (PFOS), and short-chain chlorinated paraffins (SCCPs)). In addition, the latest version of the UNECE Protocol on POPs, adopted in December 2009, severely restricts the use of gamma-hexachlorocyclohexane (lindane).

The Protocol includes provisions for dealing with the waste of substances that are banned and it obliges Parties to reduce their emissions of dioxins, furans, polycyclic aromatic hydrocarbons (PAHs) and HCB below their levels in 1990 (or an alternative year between 1985 and 1995). For the incineration of municipal, hazardous and medical waste, it lays down specific emission limit values.

On 18 December 2009, Parties to the Protocol on POPs adopted decisions 2009/1, 2009/2 and 2009/3 to amend the Protocol to include nine new substances (taking the total to 26). Furthermore, the Parties revised obligations for DDT, heptachlor, HCB and PCBs as well as certain emission limit values from waste incineration, sinter plants and electric arc furnaces for secondary steel manufacture.

5.1.2. The Stockholm Convention

The Stockholm Convention on POPs was adopted in 2001 and entered into force in 2004. **The overall objective of the Stockholm Convention is to protect human health and the environment from POPs**. It promotes global action on POPs and requires Parties to take measures to eliminate or reduce the release of POPs into the environment. Specific reference is made to a precautionary approach as set forth in Principle 15 of the 1992 Rio Declaration on Environment and Development. This principle is implemented by Article 8 of the Convention, which lays down the rules for including additional chemicals under the Convention.

At the time the Stockholm Convention entered into force in 2004, a total of 12 substances were listed in Annexes A, B and/or C comprising nine pesticides, one industrial chemical and two unintentionally created substances with no commercial value (dioxins and furans). Since 2004 additional substances have been added at subsequent Conferences of the Parties (COP).

Table V-1: Overview on POPs regulated at international level; the new POPs under the Stockholm Convention (since 2009) are highlighted in grey

Substance	CAS	Listed in Stock-holm Convention	Listed in the UNECE Protocol on POPs	Listed in the EU POP Regulation
Intentionally produced POPs				
Aldrin	309-00-2	Annex A	Yes	Yes
Chlordane	57-74-9	Annex A	Yes	Yes
Chlordecone	143-50-0	Annex A	Yes	Yes
Dieldrin	60-57-1	Annex A	Yes	Yes
Endosulfan	959-98-8 33213-65-9	Annex A	No	Yes
Endrin	72-20-8	Annex A	Yes	Yes
Heptachlor	76-44-8	Annex A	Yes	Yes
Hexabromobiphenyl (HBB)	36355-01-8	Annex A	Yes	Yes
Hexabromocyclododecane (HBCDD) (including its isomers)	25637-99-4 3194-55-6 134237-50-6 134237-51-7 134237-52-8	Annex A	No	Yes
Hexabromodiphenyl ether and heptabromodiphenyl ether	36483-60-0; 68928-80-3; and others	Annex A	Yes	Yes Yes
Hexachlorobenzene (HCB)	118-74-1	Annex A	Yes	Yes
Alpha hexachlorocyclo-hexane*	319-84-6; 608-73-1	Annex A	Yes: Hexachlorocyclohexanes (HCH; CAS: 608-73-1[37]), including lindane (CAS: 58-89-9)	Yes (all isomers including gamma HCH found in lindane)
Beta hexachlorocyclo-hexane*	319-85-7	Annex A		
Lindane*	58-89-9	Annex A		
Mirex	2385-85-5	Annex A	Yes	Yes
Pentachlorobenzene	608-93-5	Annex A	Yes	Yes
Pentachlorophenol (PCP)	87-86-5 and others	Annex A	No	Yes – added with the 2019 recast
Polychlorinated biphenyls (PCB)	1336-36-3 and others	Annex A	Yes	Yes
Tetrabromodiphenyl ether and pentabromodiphenyl ether	40088-47-9; 32534-81-9; and others	Annex A	Yes	Yes Yes
Toxaphene	8001-35-2	Annex A	Yes	Yes
DDT	50-29-3	Annex B	Yes	Yes
Perfluorooctane sulfonic acid, its salts and perfluorooctane sulfonyl fluoride (PFOS)	1763-23-1; 2795-39-3; 29457-72-5; 29081-56-9; 70225-14-8; 56773-42-3; 251099-16-8;	Annex B	Yes	Yes

[37] This CAS No. covers the isomer mixture of alpha, beta, gamma, delta and epsilon HCH.

Substance	CAS	Listed in Stock-holm Convention	Listed in the UNECE Protocol on POPs	Listed in the EU POP Regulation
	1691-99-2; 24448-09-7; 307-35-7, and others			
Perfluorooctanoic acid (PFOA), its salts and PFOA-related compounds	335-67-1	Annex A	No	Yes – added April 2020
SCCPs – short chain chlorinated paraffins	85535-84-8; and others	Annex A	Yes	Yes
HCBD – hexachlorobutadiene	87-68-3	Annex A	Yes	Yes
PCN –polychlorinated naphthalenes	70776-03-3 and others	Annex A	Yes	Yes
Bis(pentabromophenyl)ether, also known as Decabromodiphenyl ether (c-decaBDE)	1163-19-5	Annex A	No	Yes – added with the 2019 recast
Dicofol	115-32-2	Annex A	No	Yes – added June 2020
Unintentionally produced POPs				
Polychlorinated dibenzo-p-dioxins (PCDD)	1746-01-6	Annex C	Yes	Yes
Polychlorinated dibenzofurans (PCDF)	1746-01-6	Annex C	Yes	
Hexachlorobenzene (HCB)	118-74-1	Annex C	Yes	Yes
Pentachlorobenzene	608-93-5	Annex C	Yes	Yes – added with the 2019 recast
Polychlorinated Biphenyls (PCBs)	1336-36-3 and others	Annex C	Yes	Yes
PCN – polychlorinated napthalenes	70776-03-3 and others	Annex C	Yes	Yes – added with the 2019 recast
Polycyclic aromatic hydrocarbons (PAHs)	207-08-9 and others	No	Yes	Yes
HCBD – hexachlorobutadiene	87-68-3	Annex C	Yes	Yes – added with the 2019 recast

* Lindane, Alpha- and Beta hexachlorocyclohexane, as well as Chlordecone and Hexabromobiphenyl are new POPs under the Stockholm Convention but have already been covered under the POP Protocol and the EU POP Regulation.

The generic exemptions allow laboratory-scale research, use as a reference standard and unintentional trace contaminants in products and articles. Articles containing POPs manufactured or already in use before the date of entry into force of the relevant obligation are also subject to an exemption provided that Parties submit information on the uses and a national plan for waste management for such articles to the Secretariat of the Stockholm Convention.

Releases of unintentionally produced by-products listed in Annex C, including polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), PCBs, pentachlorobenzene (PeCB), HCB, PCNs and hexachlorobutadiene (HCBD), are subject to continuous minimisation with the ultimate objective of total elimination, where feasible. According to Annex C, Parties shall promote and, in accordance with their action plans, require the use of best available techniques for new sources within their major source categories identified in Part II and Part III of Annex C of the Stockholm Convention.

The Stockholm Convention also envisages **identification and safe management of stockpiles containing or consisting of POPs**. Waste containing, consisting of or contaminated with POPs shall be disposed of in such a way that the POP content is destroyed or irreversibly transformed so that it does not exhibit POPs characteristics. Where this does not represent the environmentally preferable option or where the POP content is low, waste shall be otherwise disposed of in an environmentally sound manner. Disposal operations that may lead to recovery or re-use of POPs are explicitly forbidden. With regard to shipment of wastes, relevant international rules, standards and guidelines, such as the 1989 Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, are to be taken into account.

In addition to control measures, the Stockholm Convention includes several general obligations. All Parties are obliged to develop and endeavour to implement National Implementation Plans (NIPs), facilitate or undertake the exchange of information and promote and facilitate awareness and public access to information on POPs. The Parties shall also encourage or undertake appropriate research, development, monitoring and co-operation pertaining to POPs, and where relevant, to their alternatives and candidate POPs. They shall also regularly report to the COP on the measures taken to implement the provisions of the Convention.

The Stockholm Convention recognises the particular needs of developing countries and countries with economies in transition and therefore specific provisions on technical assistance and on financial resources and mechanisms are included in the general obligations.

Extracts from the convention text relevant to waste:

Article 6 - Measures to reduce or eliminate releases from stockpiles and wastes

1. In order to ensure that stockpiles consisting of or containing chemicals listed either in Annex A or Annex B and wastes, including products and articles upon becoming wastes, consisting of, containing or contaminated with a chemical listed in Annex A, B or C, are managed in a manner protective of human health and the environment, each Party shall:

…

> *(d) Take appropriate measures so that such **wastes**, including products and articles **upon becoming wastes**, are:*
>
> *(i) Handled, collected, transported and stored in an environmentally sound manner;*
>
> *(ii) Disposed of in such a way that the persistent organic pollutant content is destroyed or irreversibly transformed so that they do not exhibit the characteristics of persistent organic pollutants or otherwise disposed of in an environmentally sound manner when destruction or irreversible transformation does not represent the environmentally preferable option or **the persistent organic pollutant content is low**, taking into account international rules, standards, and guidelines, including those that may be developed pursuant to paragraph 2, and relevant global and regional regimes governing the management of hazardous wastes;*
>
> *(iii) Not permitted to be subjected to disposal operations that may lead to recovery, **recycling**, reclamation, direct reuse or alternative uses of persistent organic pollutants; and*
>
> *(iv) Not transported across international boundaries without taking into account relevant international rules, standards and guidelines;*

Under the Basel Convention, "disposal operations" listed in Annex IV also include recovery operations, including recycling. Therefore, according to (ii) below a "low POP content", waste containing POPs can be "otherwise disposed", which includes recycling.

In its implementation into EU legislation, point (iii) is interpreted as referring to operations leading to the recovery and recycling of the POP substance as such.

5.1.3. The Basel Convention

The Basel Convention entered into force on 5 May 1992. It aims to protect human health and the environment against the adverse effects resulting from the generation, management, transboundary movements and disposal of hazardous and other wastes. It does this via a set of provisions on the transboundary movement of wastes and their environmentally sound management (ESM). In particular, the Basel Convention stipulates that any transboundary movement (export, import or transit) of wastes is permissible only when the **movement itself and the planned disposal of the hazardous or other wastes are environmentally sound**.

The concept of wastes having a "low POP content" is not as such mentioned in the Basel Convention text. The convention does however define:

*"**Environmentally sound management of hazardous wastes or other wastes**" means taking all practicable steps to ensure that hazardous wastes or other wastes are managed in a manner which will protect human health and the environment against the adverse effects which may result from such wastes;*

Article 4 of the Basel Convention refers in several of its paragraphs to the obligation of the Parties to ensure the environmentally sound management of hazardous waste and other waste. Section III of the Basel "General technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with persistent organic pollutants" (as revised in 2019) state on Low POP content:

*35. As stated in Article 6, paragraph 2 (c), of the Stockholm Convention, the Conference of the Parties to the Stockholm Convention shall cooperate closely with the appropriate bodies of the Basel Convention to "work to **establish, as appropriate, the concentration levels** of the chemicals listed in Annexes A, B and C in order **to define the low persistent organic pollutant content** referred to in paragraph 1 (d) (ii)."*

*37. The low POP content described in the Stockholm Convention is **independent** from the provisions on **hazardous waste** under the Basel Convention.*

*38. Low POP content definitions should be established **taking into account the main objective of the Basel Convention and the Stockholm Convention, which is the protection of the environment and human health**. The following have been recognized in the determination of low POP content (See European Commission, 2011, German Federal Environment Agency, 2015, UNEP/CHW/OEWG.9/INF/9/Add.13 and /Add.2,4 and UNEP/CHW.13/INF/665):*

(a) Environmental and human health considerations;

(b) Availability of adequate capacity for analysis;

(c) Range of concentrations in articles, materials and waste;

(d) Limit values within national legislation;

(e) Availability of treatment capacity;

(f) Limitations of knowledge and data; and

*(g) **Economic considerations**.*

39. The provisional definitions of low POP content contained ***in table 2 below should be applied****, determined in accordance with national or international methods and standards, except for PCDDs and PCDFs.*

The currently applicable limits under this Technical Guideline (which is not legally binding) are set in said table 2 (reproduced below).

Table 2: Provisional definitions of low POP content[6]

POP	Low POP content
Aldrin	50 mg/kg
Alpha-HCH, beta-HCH and lindane	50 mg/kg as a sum[7]
Chlordane	50 mg/kg
Chlordecone	50 mg/kg
DDT	50 mg/kg
Dieldrin	50 mg/kg
Endrin	50 mg/kg
HBB	50 mg/kg
HBCD	100 mg/kg or 1000 mg/kg
HCB	50 mg/kg
HCBD	100 mg/kg
Heptachlor	50 mg/kg
Hexabromodiphenyl ether and heptabromodiphenyl ether and tetrabromodiphenyl ether and pentabromodiphenyl ether	50 mg/kg or 1000 mg/kg as a sum[8]
[Hexabromodiphenyl ether and heptabromodiphenyl ether and tetrabromodiphenyl ether and pentabromodiphenyl ether and decabromodiphenyl ether (BDE-209) present in commercial decabromodiphenyl ether]	[[50 mg/kg] [500 mg/kg] [1000 mg/kg] as a sum[9]]
Mirex	50 mg/kg
PCBs	50 mg/kg
PCDDs and PCDFs[10]	1 µg TEQ/kg or 15 µg TEQ/kg
PCNs	10 mg/kg
PCP and its salts and esters	100 mg/kg
PeCB	50 mg/kg
PFOS, its salts and PFOSF	50 mg/kg
SCCPs	[100 mg/kg] [10 000 mg/kg]
Technical endosulfan and its related isomers	50 mg/kg
Toxaphene	50 mg/kg

The fact that for some substances several values appear in square brackets are the result of lack of agreement on a single value in Basel COP 14 (2019). Agreement may be found in the face-to-face segment of Basel COP-15 in June 2022. It is worth noting that the concept of "Maximum POP concentration limits" listed in the table in part 2 of Annex V of the EU POP regulation does not exist under the Basel (or Stockholm) Convention.

The General POP Technical Guideline also provides guidance on **pre-treatment** of POP waste:

*135. This section presents some of the **pre-treatment operations that may be required for the proper and safe operation of the disposal technologies described in subsections 2 and 3** below. There are other pre-treatment operations that may be applied. Pre-treatment operations prior to disposal in accordance with subsections IV.G.2 and IV.G.3 should be performed only if the POPs that are isolated from the waste during pre-treatment are subsequently disposed of in accordance with subsection IV.G.2. **When only part of a product or waste, such as waste equipment, contains or is contaminated with POPs, it should be separated and then disposed of as specified in subsections IV.G.1–4, as appropriate.***

*138. The **blending of waste** to create a homogeneous feedstock prior to waste treatment **may be appropriate in order to enable treatment or to optimize treatment efficiency**. However, the blending of wastes with POP contents above a defined low POP content with other materials **for the purpose of generating a mixture with a POP content at or below the defined low POP content is not environmentally sound.***

145. Mechanical separation can be used to remove larger-sized debris from the waste stream or for technologies that may not be suitable for both soils and solid wastes.

*147. **Mixing materials**, without blending, **prior to waste treatment may be appropriate in order to enable treatment or to optimize treatment efficiency**. However, the mixing of wastes with POP contents above a defined low POP content with other materials **solely for the purpose of generating a mixture with a POP content at or below the defined low POP content is not environmentally sound.***

*151. Some technologies can be used to process wastes only within a certain size limit. For example, some technologies may be used to handle POP-contaminated solid wastes only if they are less than 200 mm in diameter. **Size reduction can be used in these situations to reduce the waste components to a defined diameter**. Size reduction can include **crushing, shearing and grinding.** Other disposal technologies require slurries to be prepared prior to injection into the main reactor. It should be noted that facilities may become contaminated when reducing the size of POP wastes. Precautions should therefore be taken to prevent subsequent contamination of POP-free waste streams.*

The referred Guideline also provides guidance on other treatments for low-POP waste:

*333. If wastes with a POP content below the low POP content referred to in subsection A of section III above are not disposed of using the methods described above, they **should be disposed of in an environmentally sound manner** in accordance with pertinent national legislation and international rules, standards and guidelines, including specific technical guidelines developed under the Basel Convention.*

334. Depending on, inter alia, the type of waste stream in question, the appropriate disposal method should be chosen to manage the waste in an environmentally sound manner. For example, technical guidelines on the ESM of a number of waste streams have been developed under the Basel Convention and are available from www.basel.int.

It should be remembered that under Basel the term disposal also includes recovery operations.

5.2. THE EU POP REGULATION (EU) 2019/1021

As signatory to both the Stockholm Convention and the UNECE Protocol on POPs, the European Union created the Regulation on persistent organic pollutants (hereafter called the "POPs Regulation") to uphold the aims of the Convention and Protocol at EU level. This Regulation entered into force on 20 May 2004 and was directly applicable in all Member States, including those which are not yet Parties to the Stockholm Convention or the UNECE POP Protocol.

The POPs Regulation contains provisions regarding manufacturing, placing on the market and use of chemicals, management of stockpiles and wastes and measures to reduce releases of unintentionally produced POPs. Exports of POPs are regulated under

Regulation (EU) No 649/2012 concerning the export and import of hazardous chemicals. The exemptions to the prohibitions under the POPs Regulation are limited to a minimum. Furthermore, the POPs Regulation contains provisions requiring the setting up of emission inventories for unintentionally produced POPs, national and EU implementation plans and monitoring and information exchange mechanisms. To a certain extent the POPs Regulation goes further than the international agreements emphasising the aim to eliminate the manufacture and use of the internationally recognised POPs, notably this includes the **development of thresholds for POPs within waste, which are detailed in Annexes IV and V of the Regulation**. Where the threshold in Annex IV is exceeded the waste cannot be recycled and its disposal options are limited to a defined list of treatment, provided in Part 1 of Annex V of the Regulation, that ensure that the POP content is irreversibly transformed or destroyed[38].

Concerning management of stockpiles, the Regulation provides that **all remaining stockpiles for which no use is permitted shall be managed as waste.** Stockpiles greater than 50 kg meant for permitted uses shall be notified to the competent authority and managed in a safe, efficient and environmentally sound manner. Holders of a stockpile consisting of or containing any POPs for which no use is permitted shall manage that stockpile according to the POPs Regulation requirements.

With regard to wastes, producers and holders of waste are obliged to undertake measures to **avoid contamination of waste with POP substances**. Waste with POPs content higher than the above mentioned lower POP limits (under Annex IV) must generally be disposed of or recovered in such a way that the POP content is destroyed or irreversibly transformed. By way of derogation, wastes containing POPs below the limit values indicated in Annex V may be otherwise dealt with in accordance with a method listed in Annex V, part 2, subject to the conditions outlined in Article 7.4 (b)[39].

5.2.1. The POPs Regulation recast

The POPs Regulation has been amended several times to take into account changes within the Convention and Protocol Annexes as well as changes in other related EU legislation such as REACH. On the 22 March 2018 the European Commission adopted a proposal to recast the POPs Regulation[40]. The text of the proposal was adopted by the European Parliament on the 18 April 2019, and passed to the European Council in early May 2019. The recast of the POPs Regulation was formally published in the Official Journal of the European Union on 25 June 2019[41].

While the overall structure of the recast POPs Regulation is broadly similar to the first POPs Regulation ((EC) No 850/2004), there are a number of important changes included. As regards changes to waste and waste management, the recast provides a **stronger focus on POPs wastes and waste-management**. In particular, the recast indicates that for national reports and implementation plans Member States are encouraged to include any information on the identification of contaminated sites. Additional focus is also

[38] Subject to exceptions defined in Part 2 of Annex V.

[39] The upper concentration limits are not valid for permanent underground landfilling. Regulation (EC) 172/2007 amending Regulation (EC) 850/2004: „These limits exclusively apply to a landfill site for hazardous waste and do not apply to permanent underground storage facilities for hazardous wastes, including salt mines."

[40] COM(2018) 144 final. Proposal for a Regulation of the European Parliament and of the Council on persistent organic pollutants (recast).

[41] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019R1021&from=EN

given to management of POPs within waste streams and traceability to avoid regrettable re-entry to the market through recycling. Recital 17 of the recast specifically states:

"*In order to promote the traceability of waste containing POPs and ensure control, the provisions of the record keeping system established in accordance with Article 17 of Directive 2008/98/EC should apply also to such waste containing POPs which is not defined as hazardous waste according to Commission Decision 2014/955/EU*[42]".

This means that for wastes containing POPs, even when not classified as hazardous, the **record-keeping obligations that apply to producers or installations managing hazardous waste, will also apply,** including documenting the quantity, nature and origin of the waste and the destination of the waste. As a minimum this requires the holders of such waste to notify the competent authority of the POP content of their wastes.

In addition, following the recast of the Regulation, pursuant to its Article 15(2), amendments of Annexes IV and V (the POP waste Annexes) can only be done by co-decision, whereas under the previous regulation, this was done via implementing acts according to the regulatory procedure with scrutiny (comitology).

5.2.2. Extracts from Regulation (EU) 2019/1021 relevant to waste

Article 1 states the objectives of the Regulation:

*Taking into account, in particular, the precautionary principle, the objective of this Regulation is to protect human health and the environment from POPs by prohibiting, phasing out as soon as possible, or restricting the manufacturing, placing on the market and use of substances subject to the Stockholm Convention on Persistent Organic Pollutants, hereinafter 'the Convention', or the Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution on Persistent Organic Pollutants, hereinafter 'the Protocol', by minimising**, with a view to eliminating where feasible as soon as possible, releases of such substances, and by establishing provisions regarding waste consisting of, containing or contaminated by any of those substances.***

Article 3(6) establishes that:

*6. Waste consisting of, containing or contaminated by any substance **listed in Annex IV is regulated by Article 7**.*

Article 7 on "Waste Management" establishes that:

1. Producers and holders of waste shall undertake all reasonable efforts to avoid, where feasible, contamination of this waste with substances listed in Annex IV.

*2. Notwithstanding Council Directive 96/59/EC (24), waste consisting of, containing or contaminated by any substance listed in Annex IV to this Regulation **shall be disposed of or recovered**, without undue delay and in accordance with Part 1 of Annex V to this Regulation, in such a way as to ensure that the POP content is **destroyed or irreversibly transformed** so that the remaining waste and releases do not exhibit the characteristics of POPs. In carrying out such a disposal or recovery, any substance listed in Annex IV may be isolated from the waste, provided that this substance is subsequently disposed of in accordance with the first subparagraph.*

[42] Commission Decision 2014/955/EU of 18 December 2014 amending Decision 2000/532/EC on the list of waste pursuant to Directive 2008/98/EC of the European Parliament and of the Council (OJ L 370, 30.12.2014, p. 44).

3. Disposal or recovery operations that may lead to recovery, recycling, reclamation or re-use ***on their own of the substances*** *listed in Annex IV shall be prohibited*[43]*.*

4 .By way of ***derogation*** *from paragraph 2:*

> *(a) waste containing or contaminated by any substance listed in Annex IV* ***may be otherwise disposed of or recovered*** *in accordance with the relevant Union legislation, provided that the content of the listed substances in the waste is* ***below the concentration limits specified in Annex IV****;*
>
> *(b) a Member State or the competent authority designated by that Member State may, in exceptional cases, allow wastes listed in Part 2 of Annex V containing or contaminated by a substance listed in Annex IV up to concentration limits specified in Part 2 of Annex V to be otherwise dealt with in accordance with a method listed in Part 2 of Annex V, provided that the following conditions are fulfilled;*
>
> *…*
>
> *(i) the holder concerned has demonstrated to the satisfaction of the competent authority of the Member State concerned that decontamination of the waste in relation to substances listed in Annex IV was not feasible, and that destruction or irreversible transformation of the POP content, performed in accordance with best environmental practice or best available techniques, does not represent the environmentally preferable option and the competent authority has subsequently authorised the alternative operation;*
>
> *(ii) the holder concerned has provided information on the POP content of the waste to the competent authority;*
>
> *(iii) the operation is in accordance with relevant Union legislation and with the conditions laid down in relevant additional measures referred to in paragraph 5;*
>
> *(iv) the Member State concerned has informed the other Member States, the Agency and the Commission of its authorisation and the justification for it.*

5. The Commission may, where appropriate, and taking into consideration technical developments and relevant international guidelines and decisions and any authorisations granted by a Member State, or by the competent authority designated by that Member State in accordance with paragraph 4 and Annex V, adopt implementing acts concerning the implementation of this Article. In particular, the Commission may specify the format of the information to be submitted by Member States in accordance with point (b)(iv) of paragraph 4. Those implementing acts shall be adopted in accordance with the examination procedure referred to in Article 20(3).

6. Member States shall take the necessary measures to ensure ***the control and traceability****, in accordance with Article 17 of Directive 2008/98/EC, of waste containing or contaminated by a substance listed in Annex IV to this Regulation.*

Annex IV lists "low POP" content values for substances although it should be noted that this is terminology used in the context of the Basel Convention and that as such this term is not in the Regulation.

Annex V lists a number of destructive treatment operations in its Part A, which should be used for wastes equalling or exceeding Annex IV values, unless, the waste is one of those

[43] This refers only to the recovery of the POP substance as such, and not of a material containing the substance.

specific types listed in Part B of Annex V, which can be treated by the methods listed in column 4 "operations".

It should be noted that according to footnote (1) for those listed wastes, it is possible to exceed the Annex V limit (the maximum POP content limit - MPCL) in which case the only (other than destructive treatment) possible disposal option is in a permanent underground storage facility for hazardous waste (including salt mines).

The provisions relative to the amendment of Annexes IV and V are found in Article 15(2) of the Regulation:

Article 15(2) specifies that:

*The Commission shall keep Annexes IV and V under **constant review** and shall, **where appropriate**, make legislative proposals to amend these Annexes in order to adapt them to the **changes to the list of substances** set out in the Annexes to the Convention or the Protocol or to **modify existing entries or provisions** in the Annexes to this Regulation in order to **adapt them to scientific and technical progress.***

As regards **pre-treatment of POP waste**, part 1 of Annex V states:

*Pre-treatment operation prior to destruction or irreversible transformation pursuant to this Part of this Annex may be performed, provided that a substance listed in Annex IV that is isolated from the waste during the pre-treatment is subsequently disposed of in accordance with this Part of this Annex. **Where only part of a product or waste, such as waste equipment, contains or is contaminated with persistent organic pollutants, it shall be separated and then disposed of in accordance with the requirements** of this Regulation. In addition**, repackaging and temporary storage operations may be performed prior to such pre-treatment or prior to destruction or irreversible transformation** pursuant to this part of this Annex.*

5.2.3. Considerations as regards limits in Annex I

Article 3(1) and (2) **prohibit or restrict the manufacturing, placing on the market and use** of substances listed in **Annexes I and II**, respectively, whether on their own, in mixtures or in articles, subject to Article 4.

This is relevant given **the non-waste result of a recycling operation will be a substance, a mixture or sometimes an article**, subject to the provisions of product legislation, including Art (3) of the POP regulation, or REACH.

Article 4(1) (b) introduces the concept of "unintentional trace contaminant" (UTC):

1. *Article 3 **shall not apply** in the case of:*
   (a) a substance used for laboratory-scale research or as a reference standard;
   *(b) a substance **present as an unintentional trace contaminant**, as specified in the relevant entries of Annex I or II, **in substances, mixtures or articles**.*

Annex I of the Regulation establishes, for some substances, the value of this UTC level, for substances, mixtures and / or articles.

5.3. OTHER RELEVANT EU LEGISLATION

The **REACH Regulation** [Regulation (EC) No. 1907/2006] regulates, amongst many other aspects, the **restriction of the placing on the market and use of certain substances** listed in its Annex XVII. Consequently, restrictions cover also recycled substances and the presence of restricted substances in recovered materials. Waste as such is out of the scope of REACH. Some relevant substances, listed under the POPs Regulation are or have been previously restricted under REACH. This is the case of a number of brominated flame retardants, biocides and perfluorinated substances addressed in this impact assessment.

The **RoHS Directive** (Directive 2011/65/EU) establishes restrictions to the use of certain hazardous substances in electrical and electronic equipment. This Directive is product-specific and aims to protect human health and the environment by prohibiting the placing on the market of EEE containing certain substances above limits defined in its Annex II. Several substances relevant to this impact assessment are listed in this Annex.

Directive 2012/19/EU on **waste electrical and electronic equipment** (the WEEE Directive) addresses specific issues related to the management of this relevant and fast growing waste stream. Article 8(1) of the Directive states that all separately collected WEEE must undergo proper treatment, specifying that plastic containing brominated flame retardants (BFR) must be removed from any separately collected WEEE.

Directive 2000/53/EC on **end of life vehicles**, the "ELV Directive", requires the removal of certain components from ELVs and establishes provisions on treatment operations for depollution of end-of-life vehicles and to promote recycling.

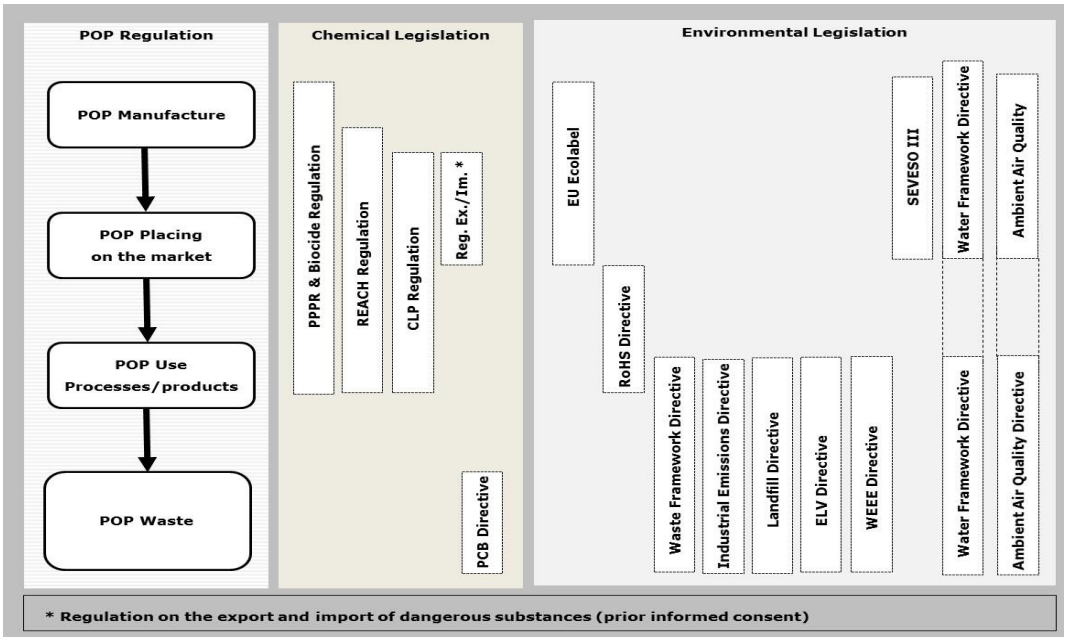


Figure V-1: Overview of the main chemical and environmental legislation relevant to POPs

The **Waste Framework Directive** (Directive 2008/98/EC) together with Decision 2000/532/EC (which establishes the "**List of Waste**") contain provisions relevant to the classification of waste. Determining whether a given waste stream is **hazardous waste** or **not** has important legal, economic and practical implications towards its collection, transport and management and is a highly relevant in this impact assessment. More

specifically Decision 2000/532/EC provides in its annex that waste containing specific listed POP substances[44] **will be classified as hazardous** if the limit value indicated in Annex IV of the POP Regulation is exceeded. This only applies to some of the POP substances listed in Annex IV and to three families of substances addressed in this impact assessment (PCDDs, PCDFs and PCBs).

Regulation (EC) No 1013/2006 on **shipments of waste** lays down procedures for the transboundary shipments of waste, addressing the problem of uncontrolled transport of waste. The Regulation implements into EU law the provisions of the "Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal" as well as of the OECD Decision[45]. The Regulation includes a ban on the export of hazardous wastes to non-OECD countries ("Basel ban") as well as a ban on the export of waste for disposal. Different regimes apply to shipments of wastes for disposal and for recovery, as well as to hazardous and "green-listed" non-hazardous wastes.

The shipment of hazardous wastes and of wastes destined for disposal is generally subject to **notification procedures** with the prior written consent of all relevant authorities of dispatch, transit and destination. This Regulation is currently in the process of being amended. It is relevant to this impact assessment because some POP waste are classified as hazardous under EU law and due to the concerns, often voiced by some Parties to the Basel Convention and by some NGOs, about the **shipment of POP wastes to developing countries**, where environmentally sound management waste cannot be guaranteed.

Regulation (EU) No 1257/2013 on **ship recycling** lays down requirements that ships and recycling facilities have to fulfil in order to make sure that ship recycling takes place in a safe and environmentally sound manner. In particular, Article 4 of the Regulation sets out measures on the control of hazardous materials on board of vessels. Notably it provides that the installation or use of hazardous materials referred to in Annex I to the Regulation, **including certain POPs** (PCBs and PFOS), shall be prohibited or restricted as specified in that Annex. In addition, Article 5 of the Regulation requires ships to carry an Inventory of Hazardous Materials (IHM) identifying the location and quantities of the hazardous materials listed in Annex I, as well as those listed in Annex II, which includes additional items, including further POPs (PBBs, PBDEs and HBCDDs).

Directive 96/59/EC on the **disposal of PCBs and PCTs**[46] seeks to ensure that **PCBs and equipment containing PCBs** are disposed of as soon as possible. Member States were required to draw up inventories of large PCB-containing equipment and adopt plans for their disposal. In addition, the Directive addresses the collection and disposal of non-inventoried equipment, such as household appliances manufactured before the ban on marketing of PCBs. The PCB Directive further mandated Member States to decontaminate or dispose of equipment containing PCB volumes of more than 5 litres by 2010.

[44] Wastes containing polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/PCDF), DDT (1,1,1-trichloro-2,2- bis (4-chlorophenyl)ethane), chlordane, hexachlorocyclohexanes (including lindane), dieldrin, endrin, heptachlor, hexaclorobenzene, chlordecone, aldrine, pentachlorobenzene, mirex, toxaphene hexabromobiphenyl and/or PCB exceeding the concentration limits indicated in Annex IV to Regulation (EC) No 850/2004 of the European Parliament and of the Council shall be classified as hazardous

[45] Decision C(2001)107/Final of the OECD Council concerning the revision of Decision C(92)39/Final on control of transboundary movements of wastes destined for recovery operations;

[46] https://ec.europa.eu/environment/waste/pcbs/index.htm

6. ANNEX VI: SUPPORTING INFORMATION BY SUBSTANCE

6.1. INTRODUCTION

The presence of POPs in recycled material represents a potential risk to the users of these materials, especially when used in consumer products, and **reduces the confidence** of supply chain operators (e.g. plastic converters) and of consumers in recycled materials. Therefore, a successful circular economy with well-functioning markets for secondary materials can only be based on safe, toxic-free materials.

The key challenge in determining the preferred policy option for wastes containing POPs is achieving an **optimum balance** between the overarching objective of eliminating POP substances from the environment and from new material cycles while at the same time **increasing recycling** and circularity while at the same time ensuring a maximum **reduction of associated greenhouse gas emissions**.

More specifically, the purpose of this impact assessment is determining the maximum levels of POP substances that **can be tolerated in waste** that can still be deemed suitable for being recycled or being subjected to **other non-destructive disposal or recovery operations**. Waste that exceeds such limits (defined in Annex IV of the Regulation) has to be destroyed, generally by incineration, or by another environmentally sound disposal option. This inevitably leads to the elimination, not only of the POP substance, but also of all the valuable material associated to it (plastic, textiles, wood, etc.).

Given that the framework for action on POPs is already defined, the discretion of the Commission is **limited to the choice of limit values**. This results in a **targeted impact assessment** that addresses 9 substances (or substance families) and multiple waste streams that contain them. Therefore the assessment is also a very granular. The tables under points 6.3 and 6.4 below provide an overview of the substances concerned and the main issues associated to setting or modifying their limits in waste.

For each of the nine substances concerned this Annex provides selected tables and supporting information that complements the summarised analysis in the main body of the impact assessment report. The main study supporting this impact assessment (RPA 2021[47]) provides a more detailed analysis of the options considered and the economic impacts, administrative burden, environmental impacts, social impacts and stakeholders' views. Further detailed supporting information is also contained in the study by Ramboll (2019)[48].

6.2. SUBSTANCES IN SCOPE

Recently listed POP substances

- **PFOA and dicofol** – these are newly listed substances under the Stockholm Convention, and therefore the Article 15(2) of the Regulation requires the Commission to, as appropriate, make legislative proposals to amend Annexes IV and V and set limit values set for them. Under the baseline, this would not happen and the EU would be in breach of its obligations.

[47] Study to support the assessment of impacts associated with the review of limit values in waste for POPs listed in Annexes IV and V of Regulation (EU) 2019/1021. European Union 2021. ISBN 978-92-76-41943-3
[48] https://ec.europa.eu/environment/waste/pdf/Study_POPS_Waste_final.pdf

- **PFHxS** - is envisaged to be listed by the Stockholm Convention in the second segment of Basel COP-15 tentatively scheduled for June 2022. Following this it would need to be included in the POPs Regulation, following the rationale described above.

- **Pentachlorophenol (PCP).** This substance had been listed in the last amendment of the previous EU POP Regulation (EC) 850/2004 but, due to administrative and timing reasons, could not be included in the recent POP recast. This issue will be now corrected.

<u>POPs already listed in the POPs Regulation where tightening could be justified</u>

- **PBDEs, HBCDD, SCCP, Dioxins & Furans (PCDD/Fs)** – are substances which are already listed in Annexes IV and V of the POPs Regulation and, therefore, would remain at their current values. The review undertaken of the value for dioxins and furans (which is a family of substances) also entails an assessment of whether it is appropriate to include therein the so-called **dioxin-like PCBs**.

Consequently, new or revised Annex IV values are being considered for PFOA and dicofol, PFHxS, Pentachlorophenol, PBDEs, HBCDD, SCCP, Dioxins & Furans (including the incorporation of dl-PCBs into the dioxins group value).

In addition, **Annex V values** are proposed for PFOA, PFHxS, Pentachlorophenol and dicofol because these are newly listed substances for which currently no values are listed in Annex V of the POP Regulation. An assessment is also done of the possibility to include the substance decaBDE into the existing group value for the other listed PBDE flame retardants.

6.3. OVERVIEW TABLE OF OPTIONS

For the purpose of the impact assessment, values have been selected from within a range of values, resulting from technical studies commissioned by the Commission and published in 2005, 2011 and 2019 as well as on existing and provisional/proposed values in legislation and guidelines[49].

	Option 1 (baseline[50])	Option 2	Option 3
PFOA[#] its salts and PFOA related compounds (mg/kg)	-	50 for PFOA and salts; 2000 for related compounds	0.025 for PFOA and salts; 1 for related compounds[#]
PFHxS[#], salts and PFHxS related compounds (mg/kg)	-	50 for PFHxS and salts; 2000 for related compounds	0.025 for PFHxS and salts; 1 for related compounds[#]
Dicofol (mg/kg)	-	-	50
Pentachlorophenol (PCP), its salts and esters (mg/kg)	-	-	100
Sum of PBDEs (mg/kg)	1,000	500	200
SCCPs (mg/kg)	10,000	1,500	420
HBCDD (mg/kg)	1,000	500	100

Table VI-1: Policy options for substances in scope of the impact assessment (except PCDD/Fs)

Note: No baseline value is available for PFOA, PFHxS, dicofol and PCP given these are newly listed substances.

#: An intermediate **Option 3bis** with a value of 1 mg/kg and 40 mg/kg, respectively, was developed in the course of the impact assessment for these two families of substances.

	Option 1 (baseline)	Option 2	Option 3	Option 4
Dioxins & furans* (mg/kg)	0.015	0.010	0.005^{+} (0.001)[#]	0.001^{++} (0.00005)[#]

Table VI-2: Policy options for PCDD/Fs

*: The appropriateness of including dioxin-like PCBs in the group value for dioxins & furans is also assessed.

+/++: For dioxins and furans, Options 3 and 4 define a generally applicable value to all waste management operations. They each include a possible sub-option which would include an additional specific limit value (in brackets) that would apply only for application of waste on land.

[49] http://www.basel.int/Implementation/POPsWastes/TechnicalGuidelines/tabid/5052/Default.aspx

[50] Current baseline values in Annex IV of the POP Regulation.

#: This sub-option is studied under the hypothesis that it may be appropriate to define a separate limit value in Annex IV that would be only applicable to certain waste management operations involving the application of the POP waste on land (e.g. spreading of sewage sludge or ashes on land for agronomic purposes). It would apply in addition to a "general value", listed in the top row, applicable to all waste. This sub-option is considered in the impact assessment, regardless of other legal or practical considerations regarding whether separate waste-treatment specific values, can be listed in Annex IV of the POPs Regulation.

6.4. OVERVIEW TABLE OF MOST RELEVANT ISSUES (NON-EXHAUSTIVE)

Substance / substance family	Relevant waste	Main issues
Polybrominated diphenyl ethers (PBDEs) [Tetrabromodiphenyl ether, pentabromodiphenyl ether, hexabromodiphenyl ether, heptabromodiphenyl ether and decabromodiphenyl ether]	WEEE plastics, ELV textiles and plastics, construction and demolition plastics, other textiles. 1,300,000 t WEEE plastic collected of which 1,000,000 is sent to specialised recyclers. About 560,000 t are recycled into new product. Another 150,000 – 400,000 t of plastic from ELV are also recycled.	• Amounts in WEEE and ELV have been decreasing due to ban of the substances. Analytical values in sorted WEEE plastics and recyclates support that values can be reduced. • Conflicting stakeholder views – clear political position of the EP and some MSs to reduce values but strong opposing views by the recycling industry that claim high negative impact on recycling and their business. • There are some limitations imposed by sorting technologies and analytical methods. • Adverse impacts on recycling possible but seem to be more related to perception and legal side-effects (classification as hazardous waste in some territories, waste shipment restrictions, distrust by customers of secondary materials). • Claims of possible negative impact on achieving WEEE and ELV recycling targets. • Already difficult market situation for recyclers due to low oil prices and COVID-19 pandemic. Competition by virgin material and low demand of recycled plastic. Risk of clear impacts on business if additional burdens are disproportionate or come about too quickly. • If the Annex IV value proposed for PBDE results in impacts that destabilise the already delicate WEEE/ELV (especially plastic) recycling sector there is a risk of relevant economic and employment impacts and of increased diversion of waste to landfill, export or illegal dumping.
Hexabromocyclododecane (HBCDD)	Expanded and extruded polystyrene insulation panels and boards (construction), EPS/XPS packaging, High-impact polystyrene WEEE plastics, back-coated textiles. Some 19,000,000 t insulation panel waste is expected to be generated in the EU until end of 2050s and beyond.	• Insulation waste with HBCDD from demolition will be generated at least over the next 50 years. • Most EPS and XPS waste exceeds current limit and most of what is separately collected is already being destroyed, reducing the need to change the existing limit values. • There are challenges to the sorting of contaminated materials and limited analytical difficulties – in particular in distinguish from new EPS insulation containing polymeric flame retardant. • Opportunities for recycling brought about by emerging chemical recycling technologies – the Polystyrene Loop project (EU funded).
Short-chain chlorinated paraffins (SCCPs).	Rubber conveyor belts, hoses, cables, seals. Soft PVC plastic articles, demolition waste (sealants, paints), imported articles. Estimated 55,000 t rubber from conveyor belts managed together with 2,619,000 t of tyre rubber waste.	• Uncertainty about amounts and types of rubber waste affected and some concern about whether tyre recycling stream is impacted by cross-contamination with conveyor belt waste. The latter seems unfounded. • Analysis of these substances is challenging. No automated sorting systems. • Economic impacts on current separately collected EPS/XPS demolition waste seem limited, given most already exceeds currently

Substance / substance family	Relevant waste	Main issues
		applicable (baseline) limit value.
Pentadecafluorooctanoic acid (PFOA) its salts and PFOA-related compounds	WEEE/ electronics (semiconductors, coatings, seals, printed circuit boards). Textiles and leather (outdoor coats, upholstered furniture, carpets). Fire-fighting foams. About 1.6 Mt of carpet waste are estimated to have been generated in the EU in 2018.	• Present in many types of articles but very limited information about concentrations in waste. • Perfluorinated substances (PFAS) are currently subject to intense regulatory attention, e.g. PFAS strategy under the Chemicals Strategy for Sustainability. • No automated sorting systems seem available. Analysis of these substances is complex and costly. • Difficult to estimate impacts, especially of the more stringent option. • Impacts on sludge relevant and may require regulatory action establishing specific values for land application under Sludge Directive (currently under review). . • Impacts on textile recycling relevant – impacts currently limited due to weak recycling performance but may be increasingly relevant in view of the envisaged Textiles Strategy and increased recycling ambitions under CEAP.
Perfluorohexane sulfonic acid (PFHxS), its salts and PFHxS-related compounds	Textiles, carpets, semiconductors, fire-fighting foams. Use in the EU other than as an impurity of PFOS has been minimal. 1.6 Mt of carpet waste generated in the EU in 2018, the amount treated with PFOS (and thereby containing PFHxS impurity) is unknown. . 15,000 – 31,000 t of firefighting foams containing PFHxS as an impurity are estimated to remain in the EU.	
Polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/PCDF) Incorporating dioxin-like PCBs also addressed here.	Dioxins can be found in waste from thermal processes – especially bottom and fly ashes from municipal waste incineration. 20,000,000 t of incinerator bottom ash are generated every year in the EU. Some 15.000.000 are recycled mostly in construction (cement, roadworks, etc). dl-PCBs can (potentially) be found in some waste oils and in waste capacitors.	• Dioxins are highly regulated and toxic substances. Expectation by NGOs and some MSs that values will be reduced. • Impact of options proposed on use of ashes in construction ranges from limited to very high. All options can have higher effects in countries with high recycling of fly ashes – eg the Netherlands and Belgium. • Impact on ashes from domestic burning of coal and wood. Could require separate collection as household hazardous waste (the relevance of this differs greatly by MSs). Other more stringent options impact ashes from biomass incineration, especially fly ashes. • NGO request for a specific (very low) limit for "untreated waste used on land" is controversial and may not be of high relevance to EU. Sewage Sludge Directive is the *lex specialis* regulating the application of waste on soil for agricultural purposes • Inclusion of dl-PCBs in the dioxin limit eems fully justified from the scientific and risk management point of view. • Analytical methods exist to detect dl-PCBs at the required low concentrations – but are more costly. • Inclusion of dl-PCB may impact recyclers of waste oils which currently apply much higher total PCB limit. Art 21 of WFD requires the COM to promote regeneration of waste oils – risk of opposite effects.
Pentachlorophenol (PCP) and its salts and esters	Treated wood (demolition, telephone poles, sleepers).Treated textiles (tarpaulins, etc). Some 23 Mt of wood is recycled in the EU of the 50 Mt collected. Contaminated wood is incinerated.	• Production and import in the EU ceased in 2002. • Treated wood is the most relevant waste stream. It is sorted out and (mostly) incinerated. • Limited information about mass flows and treatment other than in Germany • No significant impacts identified.
Dicofol	Pesticide. Agricultural use only in the EU. Production in EU ceased in 2006.	• No dicofol-containing waste streams identified in the EU. No evidence of remaining stockpiles. • Limit considered in line with other organochlorine insecticides under Basel.

6.5. BRIEF SUMMARY OF STAKEHOLDER VIEWS PER SUBSTANCE

This section aims to provide a brief overview of the main issues raised by stakeholders about the different substances addressed in the impact assessment. This review is not comprehensive and further information can be found in RPA(2021), in particular in its chapter 13 and in its individual substance chapters.

PBDEs: Stakeholder comments are very diverse regarding the impact of the preferred policy option. Operators specialising in recycling of WEEE and ELV claim that the reduction in the value will **bring about very substantial economic impacts on their activity**, resulting in an **important reduction in the amounts of WEEE/ELV plastic recycled** and the likely increase in the mismanagement or export of this waste. Other actors including NGOs and companies specialising in hazardous waste management, including by incineration, are supportive of this reduction of limit values and consider Option 3 limits can be achieved.

HBCDD: Several NGOs (eg. IPEN) have proposed that a limit of 100 mg/kg (Option 3) is proposed for HBCDD as Annex IV value. Some industrial stakeholders (HBCD Industry Group and PolyStyreneLoop) expect that Options 2 (500 mg/kg) and 3 (100 mg/kg) will have a **negative impact on future recycling** due to an anticipated need for increased analysis that may fall on SMEs in the demolition sector (these are said currently not to analyse HBCDD content in waste). It is claimed that this reduction would also result in increased costs for the PolystyreneLoop initiative itself (30% increase in treatment costs per tonne). Direct feedback received by the Commission services from associations specialising in C&D waste and in demolition confirms the lack of analytical information on HBCDD in mixed demolition waste but also seems to indicate a low likelihood of significant amounts of insulation material remaining attached to recovered aggregate.

PCDD/Fs: IPEN and other NGO stakeholders have submitted comments indicating that in their view a general limit of 0.001 mg TEQ/kg should be set for these substances, with an additional use-specific limit of 0.00005 mg TEQ/kg for waste that is disposed of on land (eg in agricultural or construction / geotechnical applications). No specific comments have been received from industry stakeholders in relation to the limits for PCDD/Fs although analytical data and direct discussions maintained with CEWEP indicate that a limit of 0.005 mg/kg is generally currently achievable for both bottom and fly ashes.

Dioxin-like PCBs: Limited feedback received on this substance. Feedback received from some industry stakeholders indicate that in their view specifically addressing dl-PCBs is not necessary given their lower toxicity as compared to dioxins (and therefore their likely low overall contribution to the total value for dioxins expressed as TEQ). Waste oil recyclers indicate that if a specific limit that is too low is imposed, significant disruptions to the regeneration of waste oils into lubricating base oils would be caused (due to interference with logistics and increased analytical costs). Waste oil recyclers have also further indicated that if a limit were to be imposed this should be done, in their view, as a joint limit with PCDD/Fs and not as a stand-alone limit for dl-PCBs[51]. The NGO IPEN and other NGOs advocate for the inclusion of dl-PCBs into the group limit for PCDD/Fs.

Short-chain chlorinated paraffins (SCCPs): IPEN and other NGOs have commented that the current Annex IV value is extremely high and advocate for a reduction to 100 mg/kg. The

[51] As indicated by GEIR this would allow the joint handling of the monitoring of dl-PCBs together with PCDD/Fs (which is already carried out and uses the same analytical method).

Finnish Environmental Institute, consulted in the supporting study, also commented on the very high value of the current limit and proposed it should be lowered to 1,500 mg/kg. During the targeted consultation with stakeholders, very limited comments have been received. ETRA and ETRMA, two industrial associations dealing with rubber products (recycling and manufacture, respectively) have indicated they expect no impact from either Options 2 or 3.

PFOA, its salts and PFOA related compounds: There have been very limited stakeholder comments as regards these substances. Two hazardous waste management associations have indicated no concern for impact of the Options proposed, whereas the German Federal Ministry for the Environment has indicated concern about the impact on textile recycling of Option 3. A number of NGOs have provided feedback suggesting an aggregated limit of 10 mg/kg which falls between Options 2 and 3. No feedback was received from stakeholders in the textile recycling sector nor from carpet manufacturers or recyclers.

PFHxS, its salts and PFHxS related compounds: See comments above for PFOA, its salts and PFOA-related substances.

Pentachlorophenol, its salts and esters: No specific comments were received from stakeholders on limits for PCP. Recent consultation with the European Panel Federation in the context of the setting, under a separate process, of an Annex I UTC value of 5 mg/kg indicated that the recycling of wood-chip into panel would not hindered by such a limit (rather to the contrary, legal certainty would be provided).

Dicofol: **T**he European Crop Care Association (ECCA) submitted comments confirming the lack of any remaining stockpiles or dicofol-contaminated waste to Ramboll (2019).

No comments or contributions have been received from stakeholders about the **Annex V limit values** proposed. This is probably explained by their extremely limited use and no envisaged impact.

6.6. SUBSTANCE-SPECIFIC SUPPORTING INFORMATION

A selection of key tables and diagrams from RPA (2021) is provided below, to support the summary provided in the body of the impact assessment report. Exhaustive information supporting the impact assessment is found in the relevant substance chapters of RPA(2021)[52] and in Ramboll (2019)[53].

6.6.1. Polybrominated diphenyl ethers (PBDEs)

Table VI-3: Final treatment of waste that contains PBDEs

Waste stream	Total waste (per year)	Incineration	Recycling	Landfill
WEEE plastics (separately collected only)	1,300,000 t/y (PBDEs: 850 t/y)	8% High Br fraction: WEEE plastics: 110,000 t/y (PBDEs: 690 t/y)	43% WEEE plastics: 560,000 t/y (PBDEs: 60 t/y)	15% WEEE plastics: 190,000 t/y (PBDEs: 25 t/y)
		36% Low Br fraction: WEEE plastics: 470,000 t/y (PBDEs: 40 t/y)		
ELV plastics	350,000 t/y (PBDEs: 50 t/y)	33% 115,000 t/y (PBDEs: 13 t)	30% 100,000 t/y (PBDEs: 19 t)	37% 130,000 t/y (PBDEs: 19 t)
ELV textiles	190,000 t/y (PBDEs: 20 t)	46% 88,000 t/y (PBDEs: 9 t/y)	8% 15,000 t/y (PBDEs: 2 t/y)	46% 88,000 t/y (PBDEs: 9 t/y)
Plastics from C&D waste	Max. 930,000 t/y (all CDW plastics but this also includes plastics with no PBDEs) Est. 10,000-60,000 t/y with PBDEs but expected to rise	Usually either landfilled or incinerated	Low except for PVC (which is not brominated) but expected to rise in the future	Usually either landfilled or incinerated
Textiles & furniture	All waste (incl. non-PBDE): 9.4 million t/y	41%	8%	41%

Table VI-1 – Final treatment of waste that contains PBDEs

Significant attention is paid to sorting and separation processes of WEEE and ELV plastics. WEEE plastic separation processes focus on creating high and low bromine (Br) fractions based on the average Br content being above or below 2,000 mg/kg (as per EN50625) as a practical method of compliance with the current PBDE LPCL of 1,000 mg/kg. The share of regulated BFRs in the total bromine content of WEEE plastic waste has been declining over time and it is estimated to have constituted around 1/6 in 2015/17 (Sofies, 2020).

[52] Study to support the assessment of impacts associated with the review of limit values in waste for POPs listed in Annexes IV and V of Regulation (EU) 2019/1021. European Union 2021. ISBN 978-92-76-41943-3

[53] https://ec.europa.eu/environment/waste/pdf/Study_POPS_Waste_final.pdf

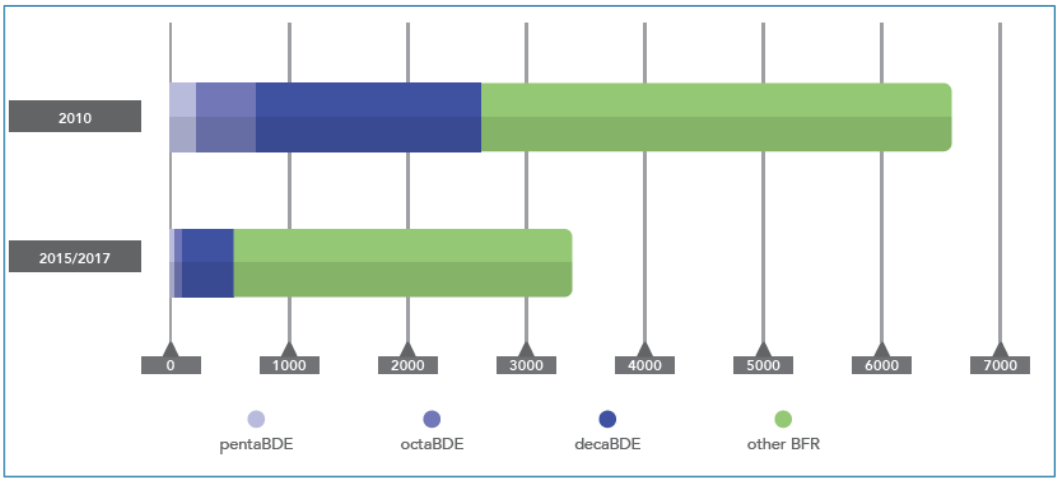


Figure VI-1 – Average BFR levels (mg/kg) in WEEE plastics (Sofies, 2020).

Sorting of WEEE plastics

WEEE sorting and pre-treatment activities relevant to this assessment focus on the separation of plastic waste into high-bromine and low-bromine fractions undertaken by specialised WEEE recyclers. This is a simplification given some separation of high-Br waste may be carried out prior to the waste reaching a specialised WEEE plastics recycler. It is also possible for WEEE plastics to be sent directly for polymer separation if they are expected to contain less than 2,000 mg Br/kg. The key steps that are relevant to the sorting of BFRs are set out below.

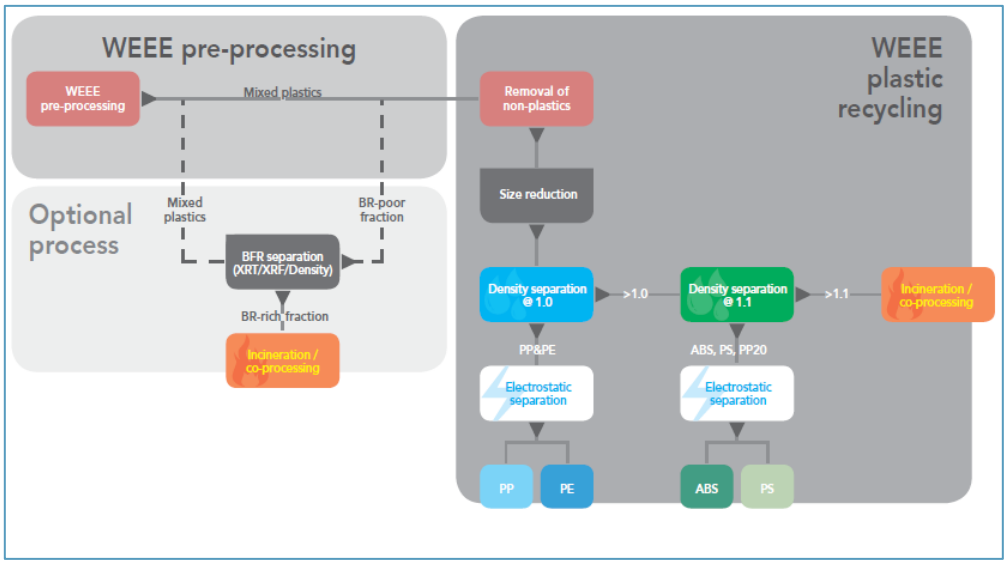


Figure VI-2 – Conventional WEEE plastic treatment processes (Sofies, 2020).

Overview of treatments and fate of WEEE plastics

The overall fate of plastics from waste electrical and electronic equipment has been analysed in Sofies (2020) which provides mass-flow information for the different polymer material types and treatments. It is important to note that, beyond the figures provided in Figure VI-3 below, a very significant amount of WEEE is unaccounted for or treated by alternative of "complementary" routes, which refers to the treatment of WEEE mixed with other ferrous or

non-ferrous metal scrap, typically under substandard conditions (e.g. lack of depollution) and escaping official WEEE accounting.

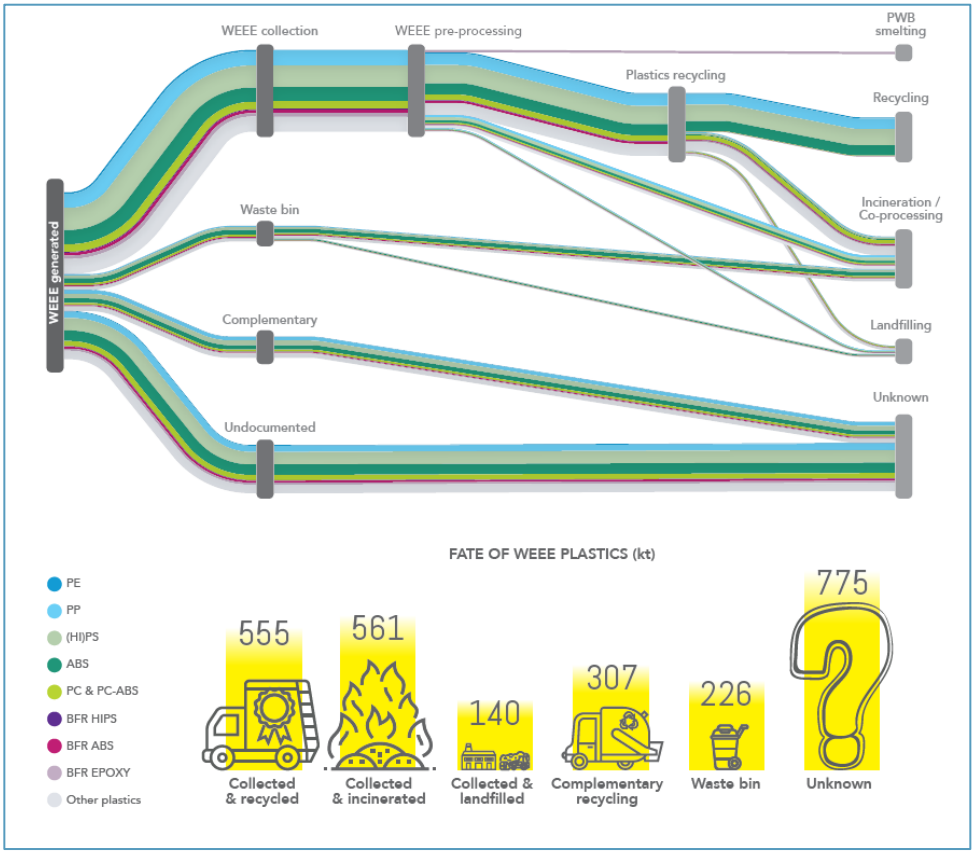


Figure VI-3 – Fate of WEEE plastics, 2020, EU-28 + Switzerland & Norway (Sofies, 2020).

Distribution of the concentrations of BFRs in different waste plastics

Table VI-4: Concentrations of PBDEs in plastics of EEE/WEEE, vehicles/ELV,CDW, and textiles

Waste stream	Substance	n	Concentration (mg/kg)			% data<					
			Median	Mean	Max	1000 mg/kg	500 mg/kg	250 mg/kg	200 mg/kg	100 mg/kg	50 mg/kg
EEE/ WEEE	PBDEs	781	7	2,663	154,000	90%	87%	85%	85%	74%	55%
	decaBDE	276	50	5,216	150,000	84%	80%	79%	79%	53%	27%
Vehicles/ ELV	PBDEs	215	6	1,623	85,000	92%	88%	85%	84%	80%	74%
	decaBDE	80	31	3,102	85,000	88%	79%	76%	75%	68%	56%
CDW	PBDEs	716	0	1,713	300,000	99%	99%	99%	99%	99%	99%
	decaBDE	81	0	8,662	300,000	95%	94%	94%	94%	94%	94%
Textile & upholstery	PBDEs	437	0	2,080	130,000	95%	94%	94%	94%	94%	93%
	decaBDE	75	0	6,511	120,000	84%	81%	81%	80%	80%	76%

Notes: A more extensive version of this table which includes exceedance of different thresholds is provided in Section 11 of RPA(2021). Published data are heterogeneous. Some are single concentration data, and others are a range of concentration data, with the report of the range values number, the minimum, the mean, and the maximum of the range. The median and mean concentrations presented here are the mean of all the single concentrations and the minimum, mean and maximum concentrations of the ranges. Some authors report the sum of BDE, that were classified POP at the time of their publication (tetra-, penta-, hexa- and hepta-BDE), under the name POP-BDE. Some authors express their results in concentration of commercial products. PBDE is the sum of all the available BDEs data for the same sample. These sources of variability are assumed to be minimised here by the large number of data.
Source: Hennebert (2020), available at https://digital.detritusjournal.com/issue/volume-12--september-2020/363

Changes in waste management costs

Table VI-5: Changed to revenues/incineration costs from WEEE/ELV waste diversion under Option 3 (200 mg/kg), € million over 2021-2035 (ENTRY INTO FORCE IN 2021)			
Waste diverted	**Incinerators**	**Recyclers**	**Landfills**
Revenue lost		11	6
Revenue gained	17		
Incineration cost		7	10
Total (gain: +, loss: -)	***+17***	***-18***	***-6***
Annual max.	+2 in 2021	-3 in 2021	-0.7 in 2021
Notes: Transport costs are not included All future costs discounted at 4% p.a. Orange/light green: transfer cost			

Table VI-6: Changed to revenues/incineration costs from WEEE/ELV waste diversion under Option 3 (200 mg/kg), € million over 2021-2035 (ENTRY INTO FORCE IN 2027)			
Waste diverted	**Incinerators**	**Recyclers**	**Landfills**
Revenue lost		*4*	3
Revenue gained	*7*		
Incineration cost		*3*	4
Total (gain: +, loss: -)	***+7***	***-6***	***-3***
Annual max.	+1.2 in 2027	-1.1 in 2027	-0.5 in 2027
Notes: Transport costs are not included All future costs discounted at 4% p.a. Orange/light green: transfer cost			

The limitation criteria that define the range for the Annex IV value are summarised below.

Table VI-7: Limitation criteria – PBDEs	
Criterion	*Concentration (mg PBDEs/kg)*
A: Analytical potential	A1: 5 mg/kg (GC-MS – laboratory) A2: 170 mg/kg (XRF – field method)
B: Background contamination	25 mg/kg
DR: Disposal and recovery capabilities	0.4 mg/kg
E: Economic feasibility	E1: 200 mg/kg E2: 350 mg/kg
LV: Existing limit value	1,000 mg/kg
MPCL: Maximum POP Content Limit	10,000 mg/kg (including decaBDE)
R : Risk (possible adverse effects on human health and the environment)	-*
UTC: Unintentional Trace Contaminant limit	**500 mg/kg**
Notes: A1: 1/6 of LOQ 30 mg Br/kg, A2: 1/6 of 1,000 Br/kg: Potential validation limitation of IEC 62321, B: Based on value of 20 mg/kg for decaBDE reported by Ramboll (2019) and increased by a factor of 25% to adjust for presence of other PBDEs, E1: Possible to achieve but would involve costs, E2: already largely achieved, easier to avoid difficulties for SMEs and unresolved uncertainties (risk of mis-sorted flakes). MPCL: Ramboll Sources: Ramboll (2019) and the analysis in this study	

*: A reliable health-based value applicable to PBDEs could not be derived for use in the methodology. See section 4.3 in Annex IV of this report. The current existing limit value agreed in 2019 (1,000 mg/kg) is used to define the upper limitation criteria.

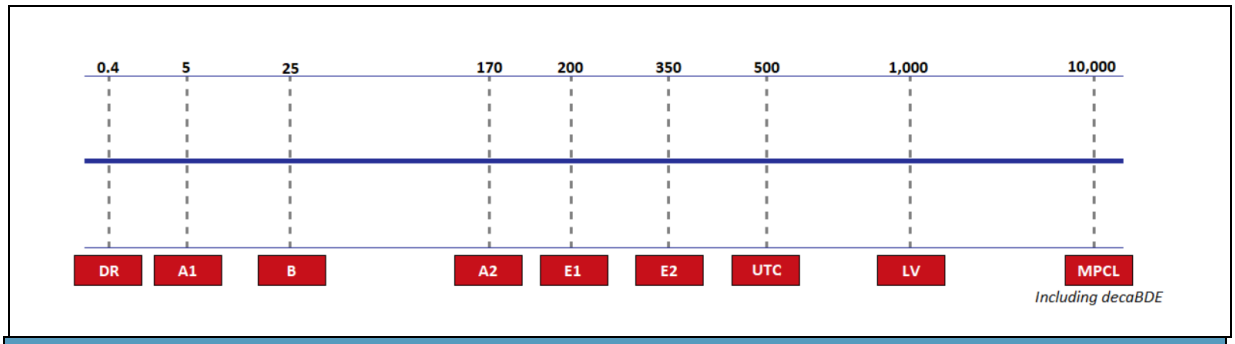


Figure VI-4: Limitation criteria - PBDEs (RPA 2021)

6.6.2. Hexabromocyclododecane (HBCDD)

Table VI-8: Overview of the relevant waste streams for HBCDD		
Waste stream	**Annual tonnage of waste**	**Concentration range (mg/kg)**
EPS: Insulation panels/boards	99,000 t in 2017	In products: 1,000 – 10,000* (not used after 2017)
XPS: Insulation panels/boards	33,000 t in 2017	In products: 6,000-29,000* (not used after 2015)
EPS/XPS: Packaging	390,000 t in 2017	In products: 5,000 – 10,000* (not used after 2015)** In waste: low (10 mg/kg in Ramboll 2019)
*Notes: *functional concentration in HBCDD-containing products ** UBA (2011) assumes last use in Germany in 2011*		

Table VI-9: Disposal and recovery methods (HBCDD)			
Waste stream	**Recycling**	**Incineration**	**Landfill**
EPS & XPS in CDW	1% / **1%**	70% / **78%**	30% / **21%**
EPS packaging	33 %	35%	32%
Note: Data in **bold** from Conversio (2020) – these data are specifically for EPS & XPS in demolition waste and exclude installation waste. Sources: Ramboll (2019), Conversio (2020)			

The limitation criteria that define the range for the Annex IV value are summarised below.

Table VI-10: Limitation criteria - HBCDD	
Criterion	*Concentration (mg/kg)*
A: Analytical potential	150 mg/kg (overall conclusion – see Sections 10.2.3 and 10.3.4 of RPA 2021 for details)
B: Background contamination	2 mg/kg*
DR: Disposal and recovery capabilities	500 mg/kg or 1,000 mg/kg (concerns with regard to mixed CDW)
E: Economic feasibility	100 mg/kg (but insufficient information on mixed CDW)
LV: Existing limit value	1,000 mg/kg
MPCL: Maximum POP Content Limit	1,000 mg/kg
R : Risk (possible adverse effects on human health and the environment)	1,000 mg/kg
UTC: Unintentional Trace Contaminant limit	100 mg/kg
Sources: Ramboll (2019) and the analysis in this study	

- *: The LOQ provided for (A) refers to GC/MS analysis of electrotechnical products, as specified in the analysis by RPA (2021) of draft standard IEC 62321-9, as this is considered the most unfavourable and relevant matrix. The lower value provided for value (B) refers to the highest reported background concentration in Europe, with an applied uncertainty factor of 10, reported in Ramboll (2019). This refers to an analysis in soil, with a much lower quantification limit.

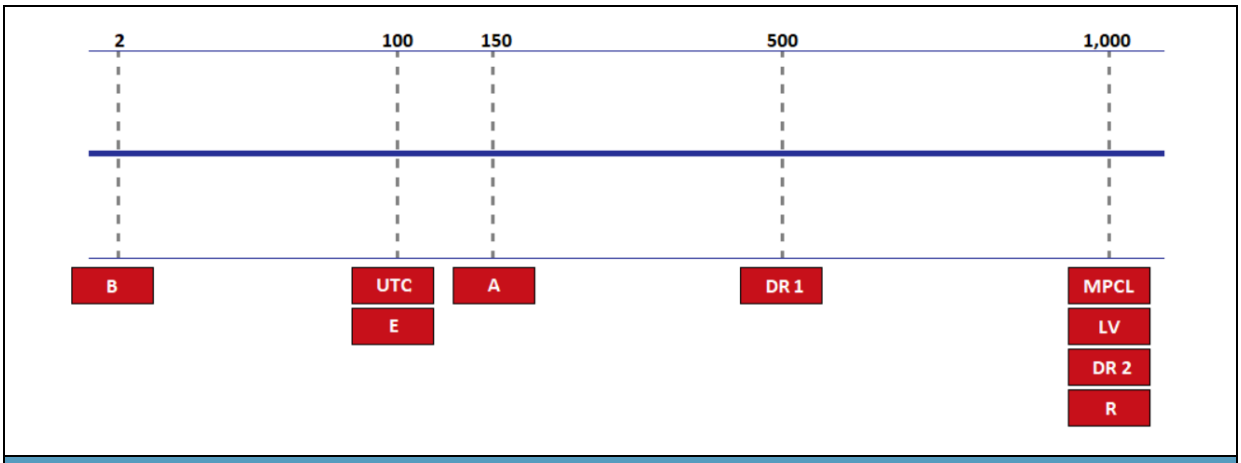


Figure VI-5: Limitation criteria - HBCDD

6.6.3. Dioxins and furans (PCDD/Fs)

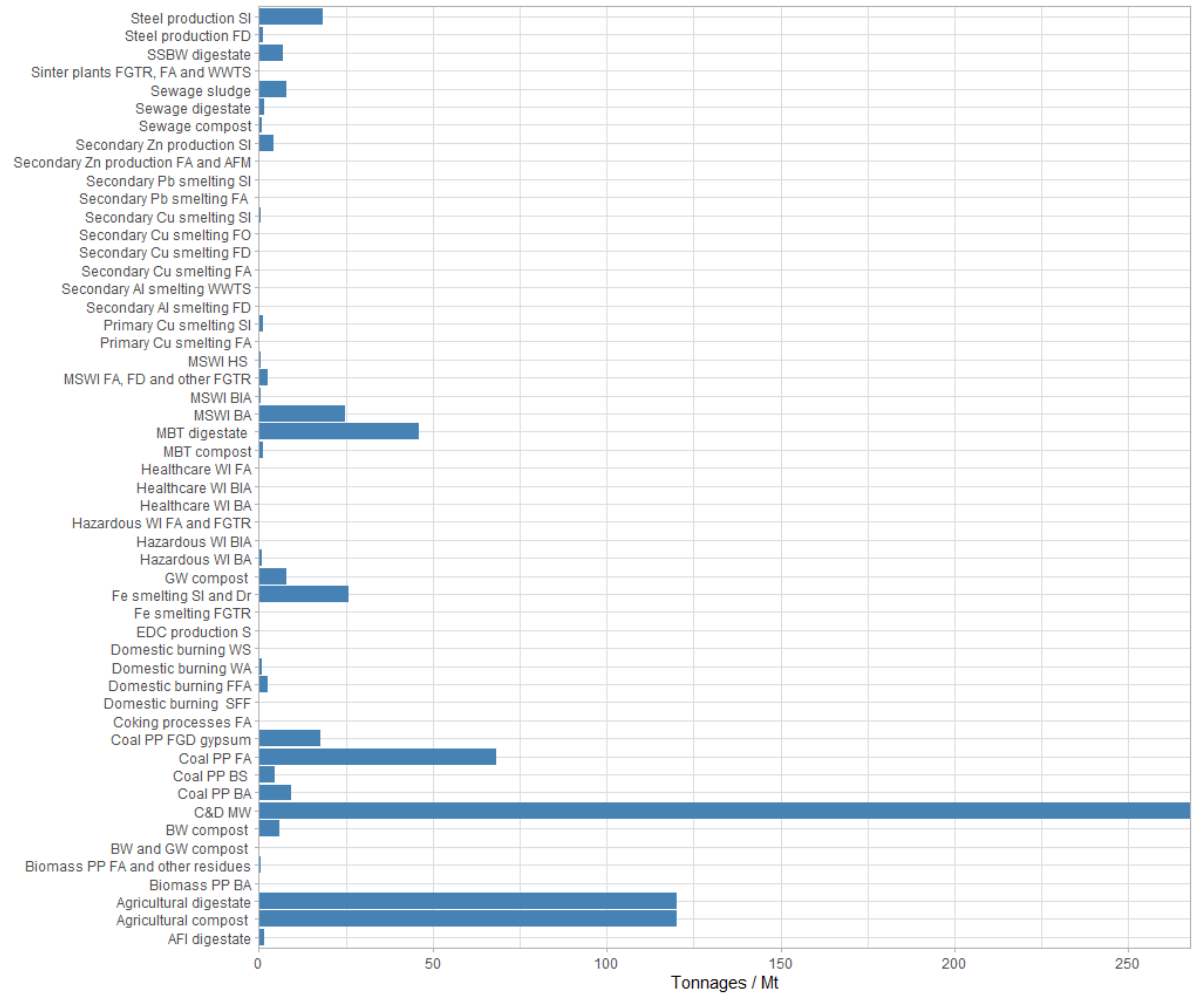


Figure IV-6: Tonnages of important sources of PCDD/Fs

An overview of the final treatment outcomes for the waste containing PCDD/Fs is shown below.

Table VI-11: Overview of the relevant disposal and recovery outcomes for waste containing PCDD/Fs

Waste stream	Waste/ product type	Non-hazardous landfill	Hazardous landfill	Construction	Agriculture and silviculture	Geotechnical applications	Temporary storage	Other
Municipal solid waste incineration	Fly ash, filter dust and other FGT residues		80% 2,044,000 t	20% 511,000 t				
	Bottom ash	40% 9,873,000 t		60% 14,809,000 t				
	Boiler ash		100% 378,000 t					
	Hydroxide sludge							100% 456,000 t hazardous waste incineration
Hazardous waste incineration	Fly ash and residues from flue gas treatment		100% 274,000 t					

Table VI-11: Overview of the relevant disposal and recovery outcomes for waste containing PCDD/Fs								
Waste stream	**Waste/ product type**	**Non-hazardous landfill**	**Hazardous landfill**	**Construction**	**Agriculture and silviculture**	**Geotechnical applications**	**Temporary storage**	**Other**
	Boiler ash		100% 219,000 t					
	Bottom ash		100% 927,000 t					
Healthcare waste incineration	Bottom ash	70% 29,000 t		30% 12,000 t				
	Fly ash and boiler ash		97% 33,027 t				3% 1,000 t	
Coal power production	Fly ash		5% 3,415,000 t	35% 23,905,000 t	0.2% 204,000 t	58% 39,614,000 t	1% 68,000 t	1% 68,000 t other uses
	Bottom ash	8% 752,000 t		26% 2,444,000 t		64% 6,016,000 t	2% 188,000 t	
	Boiler slag	6% 276,000 t		15% 690,000 t				80% 3,680,000 t metallurgical purposes
	Flue-gas desulphurisation gypsum	10% 1,947,000 t		75% 13,275,000 t		11% 1,947,000 t	4% 708,000 t	
Coking processes	Fly ash	9% 27,000 t		78% 234,000 t		9% 27,000 t	4% 12,000 t	
Biomass power production	Fly ash	70% 383,000 t		10% 58,000 t	10% 58,000 t	10% 58,000 t		
	Bottom ash	70% 43,000 t		10% 6,000 t	10% 6,000 t	10% 6,000 t		
Ethylene dichloride production	Sludge							100% 2,400 t incineration with hazardous waste
Sinter plants	Residues from FGT, fly ashes and wastewater treatment sludge	25% 15,000 t						75% 45,000 t internally recycled
Steel production (electric arc 40% and blast furnaces 60%)	Slag	60% 11,040,000 t		33% 6,072,000			2% 368,000 t	5% 920,000 t internally recycled
	Filter dust	45% 11,94,750 t					5% 133,000 t	5% 133,000 t internally recycled, 45% 1,195,000 t Waelz process
Iron smelting	Slag and dross	50% 12,900,000 t						50% 12,900,000 t internally recycled
	Used sand							100% 780,000 t internally recycled
	Residues from FGT	100% 69,000 t						
Primary copper smelting	Fly ash							100% 11,000 t recycled in the Waelz process
	Slag			50% 545,000 t		30% 327,000 t		20% 218,000 t secondary copper smelting
Secondary copper smelting	Fly ash and filter dust		100% 13,000 t					
	Furnace lining		100% 13,000 t					
	Slag			100% 1,333,000 t				
	Furnace oxide							100% 211,000 t secondary zinc and lead production
Secondary aluminium	Filter dust		77% 33,000	23% 10,000				

Table VI-11: Overview of the relevant disposal and recovery outcomes for waste containing PCDD/Fs								
Waste stream	**Waste/ product type**	**Non-hazardous landfill**	**Hazardous landfill**	**Construction**	**Agriculture and silviculture**	**Geotechnical applications**	**Temporary storage**	**Other**
smelting	Sludge from WWT		100% 5,000 t					
Secondary lead smelting	Fly ash		100% 7,000 t					
	Slag		60% 154,710					40% 103,000 t metal recovery
Secondary zinc production	Fly ash							
	Slag		36% 1,500,000 t	64% 2,700,000 t				
	Absorption and filter material	1% 50 t						99% 5,000 t recycling/recovery
Construction and demolition waste	Mineral waste	12% 30,860,000 t	1% 2,990,000 t			8% 21,520,000 t		0.2% 50,000 t incineration; 0.52% 1,380,000 t energy recovery; 79% 210,940,000 t recycling
Compost/ digestate	Agricultural digestate				50% 60,000,000 t			50% 60,000,000 t horticulture, domestic fertiliser
	Digestate from agro-food industry by-products				50% 850,000 t			50% 850,000 t horticulture, domestic fertiliser
	Agricultural compost				100% 120,000,000 t			
	MBT digestate	100% 46,000,000 t						
	MBT compost	100% 1,266,315 t						
	Source separated biowaste digestate				50% 7,000,000 t			50% horticulture, (domestic fertiliser)
	Biowaste compost				80% 4,800,000 t			20% 1,200,000 t horticulture, domestic fertiliser and other use
	Bio and green waste compost				50% 50,000 t			50% 50,000 t horticulture
	Green waste compost				20% 1,600,000 t			80% 6,400,000 t horticulture, parks and gardens, domestic fertiliser
Sewage sludge	Sewage sludge	16% 1,280,000 t						38% 3,040,000 t sludge incinerated or used of energy recovery with municipal solid waste 21% 1,680,000 t compost 25% 2,000,000 t digestate
	Sewage sludge digestate	50% 400,000 t						50% 400,000t incinerated
	Sewage sludge				100%			

Table VI-11: Overview of the relevant disposal and recovery outcomes for waste containing PCDD/Fs								
Waste stream	**Waste/ product type**	**Non-hazardous landfill**	**Hazardous landfill**	**Construction**	**Agriculture and silviculture**	**Geotechnical applications**	**Temporary storage**	**Other**
	compost				1,700,000 t			
Domestic burning	Ash (fossil fuels)				20% 543,000 t			80% 2,173,000 t municipal solid waste
	Soot (fossil fuels)				20% 3,000 t			80% 11,000 t municipal solid waste
	Ash (wood)				20% 174,000 t			80% 694,000 t municipal solid waste
	Soot (wood)				20% 3,000 t			80% 12,000 t municipal solid waste
Note: According to Annex V of the POPs Regulation, wastes from thermal processes which contain PCDD/Fs exceeding 5 mg/kg can be stored permanently in safe, deep, underground, hard rock formations, salt mines or a landfill site for hazardous waste.								

Table VI-12: Maximum tonnages that could potentially be impacted by the policy options					
Waste	**Option 2 (0.01 mg/kg TEQ)**	**Option 3 (0.005 mg/kg TEQ)**	**Option 3 (+land) (0.001 mg/kg TEQ)**	**Option 4 (0.001 mg/kg TEQ)**	**Option 4 (+land) (0.0005 mg/kg TEQ)**
Domestic wood and coal burning soot and ashes	36,000-72,000 t cannot be used in agriculture 181,000-361,000 t for hazardous landfill or underground storage	36,000-145,000 t cannot be used in agriculture 181,000-723,000 t for hazardous landfill or underground storage	36,000-181,000 t cannot be used in agriculture 181,000-903,000 t for non-hazardous or hazardous landfill or underground storage	36,000-181,000 t cannot be used in agriculture 181,000-903,000 t for hazardous landfill or underground storage	72,000-361,000 t cannot be used in agriculture 181,000-903,000 t for hazardous landfill or underground storage 36,000-181,000 t for non-hazardous landfill
Biomass power production fly ash and other residues		8,000-33,000 t cannot be used in agriculture, construction or geotechnical applications 27,000-110,000 t for hazardous landfill or underground storage	8,000- 41,000 t cannot be used in agriculture, construction or geotechnical applications 27,000-110,000 t for hazardous landfill or underground storage Up to 8,000 t for non-hazardous landfill	8,000-41,000 t cannot be used in agriculture, construction or geotechnical applications 27,000-137,000 t for hazardous landfill or underground storage	16,000-82,000 t cannot be used in agriculture, construction or geotechnical applications 27,000-137,000 t for hazardous landfill or underground storage 8,000-41,000 t for non-hazardous landfill
Municipal solid waste incineration fly ash, filter dust and other residues			26,000-128,000 t cannot be used in construction 26,000-128,000 t for non-hazardous landfill, hazardous landfill or underground storage	26,000-128,000 t cannot be used in construction 26,000-128,000 t for hazardous landfill or underground storage	51,000-256,000 t cannot be used in construction 51,000-256,000 t for non-hazardous landfill, hazardous landfill or underground storage
Agricultural digestate					12,000,000-60,000,000 t cannot be used in agriculture or horticulture /domestic fertiliser 12,000,000-60,000,000 for non-hazardous landfill
Construction and demolition mineral waste					2,152,000-10,760,000 t cannot be used in geotechnical applications 21,094,000-

Table VI-12: Maximum tonnages that could potentially be impacted by the policy options						
Waste		Option 2 (0.01 mg/kg TEQ)	Option 3 (0.005 mg/kg TEQ)	Option 3 (+land) (0.001 mg/kg TEQ)	Option 4 (0.001 mg/kg TEQ)	Option 4 (+land) (0.0005 mg/kg TEQ)
						105,470,000 t cannot be recycled 23,246,000-116,230,000 t for non-hazardous landfill
Municipal solid waste incineration bottom ash						1,481,000-7,405,000 t cannot be used in construction 1,481,000-7,405,000 t for non-hazardous landfill
Totals	Not used in agriculture	36,000-72,000 t	38,667-156,000 t	38,667-194,667 t	38,667-194,667 t	6,077,333-30,388,333 t
	Not used in construction		2,667-11,000 t	28,667-141,667 t	28,667-141,667 t	1,537,333-7,688,333 t
	Not used in geotechnical applications		2,667-11,000 t	2,667-13,667 t	2,667-13,667 t	2,157,333-10,787,333 t
	Not used in horticulture/as domestic fertiliser					6,000,000-30,000,000 t
	Not recycled					21,094,000-105,470,000 t
	Hazardous landfill	181,000-361,000 t	208,000-833,000 t	231,400-948,200 t	234,000-1,168,000 t	253,900-1,270,400 t
	Non-hazardous landfill			2,600-200,800 t		36,776,100-183,882,600

Source:
RPA's own analysis using sources shown in the Relevant Waste Streams Section.
Method:
The methodology for each of the options is as follows where the typical waste PCDD/F concentrations are above the proposed limits:
Option 1: baseline.
Option 2: 5-10% reduction in non-hazardous landfill and applications on land.
Option 3: 5-20% reduction in non-hazardous landfill and applications on land.
Option 3 (land): 5-25% reduction in applications on land.
Option 4: 5-25% reduction in non-hazardous landfill and applications on land.
Option 4 (land): 10-50% reduction in applications on land.

Table VI-13: Additional costs of landfilling of the different wastes that are impacted by the policy options (€ per year)					
Waste	Option 2 (0.01 mg/kg TEQ)	Option 3 (0.005 mg/kg TEQ)	Option 3 (+land) (0.001 mg/kg TEQ)	Option 4 (0.001 mg/kg TEQ)	Option 4 (+land) (0.0005 mg/kg TEQ)
Domestic burning soot and ashes	39,820,000-79,420,000	39,820,000-159,060,000	39,820,000-168,060,000	39,820,000-198,660,000	41,620,000-207,710,000
Biomass power production fly ash and other residues		6,075,000-24,750,000	6,075,000-25,150,000	6,075,000-30,825,000	6,475,000-32,875,000
Municipal solid waste incineration fly ash, filter dust and other residues			6,214,000-30,592,000	6,760,000-33,280,000	12,189,000-61,184,000
Agricultural digestate					600,000,000-3,000,000,000
Construction and demolition mineral waste					1,162,300,000-5,811,500,000
Municipal solid waste incineration bottom ash					74,050,000-370,250,000
Totals	39,820,000-79,420,000	45,895,000–183,810,000	52,109,000–223,802,000	52,655,000–262,765,000	1,896,634,000–9,483,519,000

Table VI-13: Additional costs of landfilling of the different wastes that are impacted by the policy options (€ per year)					
Waste	**Option 2 (0.01 mg/kg TEQ)**	**Option 3 (0.005 mg/kg TEQ)**	**Option 3 (+land) (0.001 mg/kg TEQ)**	**Option 4 (0.001 mg/kg TEQ)**	**Option 4 (+land) (0.0005 mg/kg TEQ)**

Source:
RPA's own analysis based on the sources elsewhere in this section (Section 7), including current final treatment methods in Table 7-8.
https://ec.europa.eu/environment/waste/studies/pdf/eucostwaste.pdf
Method:
Domestic burning soot and ashes: Where waste is diverted to hazardous landfill/underground storage, 80% is diverted from non-hazardous landfills at a cost of €210/tonne (gate fees for hazardous landfill: €260/tonne, non-hazardous landfill: €50/tonne, see Section 3) and 20% is diverted from agriculture at a cost of €260/tonne. Average cost of diversion is therefore: €220. Under Options 3+land and 4+land, some waste is also expected to be diverted from agriculture to non-hazardous waste landfills at a cost of €50/tonne.
Biomass power production fly ash and other residues: Under Options 3 and 4, waste is diverted to hazardous landfill/underground storage, 70% diverted from non-hazardous landfills at a cost of €210/tonne and 30% diverted from agriculture, construction and geotechnical applications at a cost of €260/tonne. Average cost of diversion is therefore: €225. Under the '+land' options, additional waste diverted from agriculture, construction and geotechnical applications (which is not diverted under the non-land options) is all expected to be sent to non-hazardous waste landfills at a cost of €50/tonne.
Municipal solid waste incineration fly ash, filter dust and other residues: All waste is diverted from application in construction. Under Options 3+land and 4+land, 90% of diverted waste is expected to be sent to hazardous landfills/underground storage at a cost of €260/tonne and 10% is expected to be sent to non-hazardous landfills at a cost of €50/tonne. Under Option 4, all diverted waste is sent to hazardous landfills/underground storage at a cost of €260/tonne.
Agricultural digestate: all agricultural digestate is expected to be diverted from agricultural and horticultural use to non-hazardous waste landfills at a cost of €50/tonne.
Construction and demolition mineral waste: expected to be diverted to non-hazardous waste landfills at a cost of €50/tonne.
Municipal solid waste incineration bottom ash: all bottom ashes that can no longer be used in construction are expected to be diverted to non-hazardous waste landfills at a cost of €50/tonne.

Table VI-14: Releases to land / g TEQ under the different policy options						
Waste sector	**Option 1 (0.015 mg/kg TEQ)**	**Option 2 (0.01 mg/kg TEQ)**	**Option 3 (0.005 mg/kg TEQ)**	**Option 3 (+land) (0.001 mg/kg TEQ)**	**Option 4 (0.001 mg/kg TEQ)**	**Option 4 (+land) (0.0005 mg/kg TEQ)**
Municipal solid waste incineration	47	47	47	**48-50**	47	**53-76**
Hazardous waste incineration	0	0	0	0	0	0
Healthcare waste incineration	16	**14-15**	**13-15**	**12-15**	12-15	**9-14**
Coal power production	75	75	75	75	75	75
Coking processes	2	2	2	2	2	2
Biomass power production	947	947	**765-901**	**721-899**	**710-899**	**541-857**
Ethylene dichloride production	0	0	0	0	0	0
Sinter plants	0	0	0	0	0	0
Steel production	14	6	6	6	6	**3-5**
Iron smelting	79	79	79	79	79	**46-73**
Primary copper smelting	0	0	0	0	0	0
Secondary copper smelting	0	0	0	0	0	0
Secondary aluminium smelting	0	0	0	0	0	0
Secondary lead smelting	0	0	0	0	0	0
Secondary zinc production	42	42	42	42	42	42
Construction and demolition waste	1,523	1,523	1,523	1,523	1,523	**854-1,389**
Compost/digestate	17,844	17,844	17,844	17,844	17,844	**9,528-16,181**
Sewage sludge	11	11	11	11	11	11
Domestic burning	277	**270-274**	**262-274**	**260-274**	259-274	**149-251**
Total	20,869	20,860-20,865	20,670-20,819	20,626-20,818	20,610-20,817	11,337-18,953
Overall reduction		4-9	50-199	51-243	52-260	1,916-9,532

*Figures in red indicate where the PCDD/F release to land has increased. This is because the leaching rate from non-hazardous landfill (1%) is higher than the leaching rate for construction (0.1%). This is expected to be a worst-case scenario that may overestimate the actual releases as a result of the policy option – see the discussion preceding this table (in RPA (2021).
Leaching rate of 1% was chosen for non-hazardous landfill and 0.1% for recycling in construction.

The limitation criteria that define the range for the Annex IV value are summarised below.

Table VI-15: Limitation criteria – PCDD/Fs	
Criterion	**Concentration (mg PBDEs/kg)**
A: Analytical potential (for waste residues, ash and slag)	0.000001 mg/kg
B: Background contamination (moss)	B1: 0.0000000001 mg/kg B2: 0.000056 mg/kg
DR: Disposal and recovery capabilities	0.005 mg/kg
E: Economic feasibility	E1: 0.01 mg/kg E2: 0.005 mg/kg E3: 0.001 mg/kg
LV: Existing limit value	0.015 mg/kg
MPCL: Maximum POP Content Limit	5 mg/kg
R : Risk (possible adverse effects on human health and the environment)	R1 - 0.000050 mg/kg (agricultural application on land) R2 – 0.015 (other waste recovery / disposal)
Notes: E1: Largely achieved, E2: possible to achieve but would involve costs to biomass power plants, E3: possible to achieve but would involve costs to MSWI fly ash users, MPCL: Ramboll (2019). Sources: Ramboll (2019), BiPRO (2005), Eurofins, (2013) and the analysis in this study. Danielsson, H., Hansson, K., Potter, A., Friedrichsen, J. and Brorström-Lundén, E., 2016. Persistent organic pollutants in Swedish mosses. Dreyer, A., Nickel, S. and Schröder, W., 2018. (Persistent) Organic pollutants in Germany: results from a pilot study within the 2015 moss survey. Environmental Sciences Europe, 30(1), pp.1-14.	

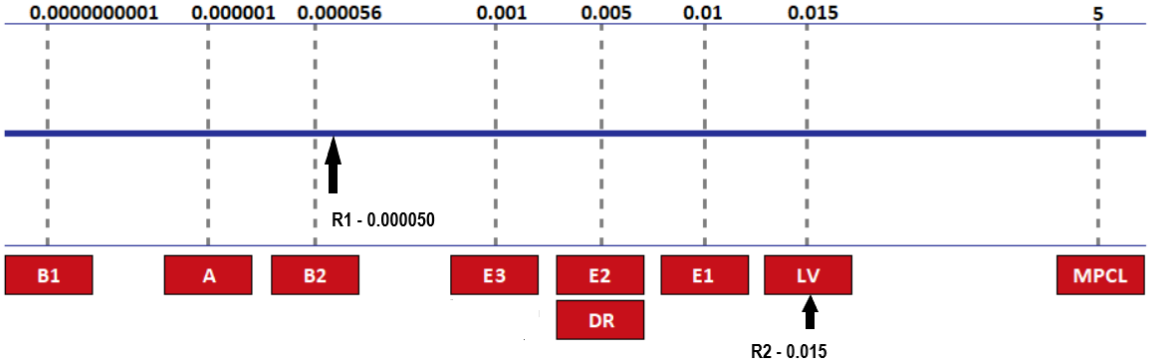


Figure VI-7: Limitation criteria diagram for PCDD/Fs + dl-PCBs – adapted from RPA (2021)

6.6.4. Dioxin-like PCBs

Table VI-16 : I-TEF$_{WHO}$ (2005)	
Congeners	**I-TEF$_{WHO}$ (2005)**
Chlorinated dibenzo -p-dioxins	
2,3,7,8-TCDD	1
1,2,3,7,8 -PeCDD	1
1,2,3,4,7,8-HxCDD	0.1
1,2,3,6,7,8-HxCDD	0.1
1,2,3,7,8,9-HxCDD	0.1
1,2,3,4,6,7,8-HpCDD	0.01
OCDD	0.0003
Chlorinated dibenzofurans	
2,3,7,8-TCDF	0.1
1,2,3,7,8 -PeCDF	0.03
2,3,4,7,8 -PeCDF	0.3
1,2,3,4,7,8-HxCDF	0.1
1,2,3,6,7,8-HxCDF	0.1

Table VI-16 : I-TEF$_{WHO}$ (2005)	
Congeners	**I-TEF$_{WHO}$ (2005)**
1,2,3,7,8,9-HxCDF	0.1
2,3,4,6,7,8-HxCDF	0.1
1,2,3,4,6,7,8-HpCDF	0.01
1,2,3,4,7,8,9-HpCDF	0.01
OCDF	0.0003
Polychlorinated biphényls	
Non-ortho substituted PCBs	
PCB 77	0.0001
PCB 81	0.0003
PCB 126	0.1
PCB 169	0.03
Mono-ortho substituted PCBs	
PCB 105	0.00003
PCB 114	0.00003
PCB 118	0.00003
PCB 123	0.00003
PCB 156	0.00003
PCB 157	0.00003
PCB 167	0.00003
PCB 189	0.00003

Table VI-17: Synthesis of the inclusion of dl-PCB in the main European legislation

Regulations			Use of WHO Tef values for dl-PCB	Comments	Calculation of/or limit values
Organization	No.	Object			
EU	1259/2011	maximum levels for PCDD, dl-PCBs and ndl-PCBs in foodstuffs	WHO TEFs are recommended for all dl-PCBs (PCB-77, PCB-81, PCB-126, PCB-169, PCB-105, PCB-114, PCB-118, PCB-123, PCB-156, PCB-157, PCB-167, PCB-189)	This regulation proposes the calculation of 3 different limit values	Sum of dioxins = (sum of PCDD and PCDF, expressed in WHO toxic equivalents after application of TEFs) Sum of dioxins and dl-PCB = (sum of PCDD, PCDF, dl-PCB, expressed in WHO toxic equivalents after application of TEFs) sum of ndl-PCB
EU	1067/2013	maximum levels of the contaminants dioxins, dioxin-like PCBs and non-dioxin-like PCBs in liver of terrestrials animals	WHO TEFs are recommended for all dl-PCBs (PCB-77, PCB-81, PCB-126, PCB-169, PCB-105, PCB-114, PCB-118, PCB-123, PCB-156, PCB-157, PCB-167, PCB-189)	This regulation proposes the calculation of 3 different limit values	Sum of dioxins = (sum of PCDD and PCDF, expressed in WHO toxic equivalents after application of TEFs) Sum of dioxins and dl-PCB = (sum of PCDD, PCDF, dl-PCB, expressed in WHO toxic equivalents after application of TEFs) sum of ndl-PCB
EU	2013/39/EU	priority substances for water policy	WHO TEFs are recommended for all dl-PCBs (PCB-77, PCB-81, PCB-126, PCB-169, PCB-105, PCB-114, PCB-118, PCB-123, PCB-156, PCB-157, PCB-167, PCB-189)		sum of PCDD+PCDF+ dl-PCB
EU	Commission implementing decision (EU) 2019/2010	best available techniques (BAT) conclusions for waste incineration under Directive 2010/75 / EU	WHO TEFs are recommended for all dl-PCBs (PCB-77, PCB-81, PCB-126, PCB-169, PCB-105, PCB-114, PCB-118, PCB-123, PCB-156, PCB-157, PCB-167, PCB-189)		sum (PCDD / PCDF) expressed in ng I-TEQ / Nm^3 sum (PCDD / PCDF + dl-PCB) expressed in ng WHO-TEQ /Nm^3

6.6.5. Short-chain chlorinated paraffins (SCCPs)

Table VI-18: Overview of the current disposal and recovery methods (SCCPs)				
Waste stream	**Total waste in 2020**	**Incineration**	**Recycling**	**Landfill**
Rubber waste from conveyor belts	Total rubber waste from all rubber conveyor belts: ~50,000 tonnes SCCPs: 413 tonnes *SCCP concentration: ~8,260 mg/kg*	Based on information from literature review, desk research and consultation with stakeholders, we assume that 50% of conveyor belts used for underground mining are incinerated	Based on information from literature review, desk research and consultation with stakeholders, we assume that 50% of conveyor belts used for underground mining are recycled	Unlikely
Sealants & Adhesives (S&A) that can be separated from other mineral CDW (1/3)	810 tonnes of SCCP containing S&A SCCPs: 162 tonnes	810 tonnes of SCCP containing S&A SCCPs: 162 tonnes	Unlikely	Unlikely
S&A that cannot be separated from other mineral CDW (2/3): Treated with other mineral construction and demolition waste	*Scenario A – If treated with non-hazardous mineral CDW:* Total non-hazardous mineral CDW: 320,310,000 tonnes SCCPs: 324 tonnes *SCCP concentration: ~1mg/kg*	940,000 tonnes SCCPs: 1 tonne *SCCP concentration: ~1mg/kg*	287,010,000 tonnes SCCPs: 290 tonnes *SCCP concentration: ~1mg/kg*	32,360,000 tonnes SCCPs: 33 tonnes *SCCP concentration: ~1mg/kg*
	Scenario B – If treated with hazardous mineral CDW: Total hazardous mineral CDW: 9,140,000 tonnes SCCPs: 324 tonnes *SCCP concentration: ~35.5mg/kg*	490,00 tonnes SCCPs: 17.5 tonne *SCCP concentration: ~35.5mg/kg*	5,640,000 tonnes SCCPs: 200 tonnes *SCCP concentration: ~35.5mg/kg*	3,010,000 tonnes SCCPs: 107.5 tonnes *SCCP concentration: ~35.5mg/kg*
Source: Estimated by the study team based on data retrieved from Eurostat and approach adopted by BiPRO (2011), BiPRO (2015a) and Ramboll (2019)				

Table VI-19: Changes to revenues/incineration cost under Option 2 (1,500 mg/kg) and Option 3 (420 mg/kg) - conveyor belt rubber (Present value, € million over 2021-2035)			
Waste diverted	**Incinerators**	**Recyclers / collectors**	**Waste generators**
Option 2			
Revenue lost	-	-1.3 to 12.4	-
Revenue gained	+1.7 to 16.2	-	-
Incineration	-	-1.7 to 16.2*	
Total (gain: +, loss: -)	***+1.7 to 16.2***	***-3 to 28.6***	
Annual max.	0.5-2.6	-4.6	
Option 3			
Revenue lost	-	-1.4 to 16.8	
Revenue gained	1.8 to 21.8	-	
Incineration	-	-1.8 to 21.8	

Table VI-19: Changes to revenues/incineration cost under Option 2 (1,500 mg/kg) and Option 3 (420 mg/kg) - conveyor belt rubber (Present value, € million over 2021-2035)			
Waste diverted	**Incinerators**	**Recyclers / collectors**	**Waste generators**
Total (gain: +, loss: -)	***+1.8 to 21.8***	***-3.2 to 38.5***	
Annual max.	0.5-2.6	-4.6	
Notes: Transport costs not included All future costs discounted at 4% p.a. Orange/light green: transfer cost *It is not clear how the increased cost of incineration would be split between waste generator and recycler/collector.			

The limitation criteria that define the range for the Annex IV value are summarised below.

Table VI-20: Limitation criteria - SCCPs	
Criterion	*Concentration (mg/kg)*
A: Analytical potential	Cl by XRF: 30 mg Cl/kg Laboratory test: potentially 0.03 mg/kg
B: Background contamination	1 mg/kg (based on values reported for Germany of 0.083 mg/kg, an uncertainty factor of 10 and rounded).
DR: Disposal and recovery capabilities	Sufficient capacity for Option 3 (420 mg/kg) Ramboll (2019): 1 mg/kg (not reassessed in this study but it should be noted that most recent data on incineration capacity is lower than estimated in Ramboll 2019)
E: Economic feasibility	Where data are available 420 mg/kg is economically feasible
LV: Existing limit value	10,000 mg/kg
MPCL: Maximum POP Content Limit	10,000 mg/kg
R : Risk (to human health and the environment)	18,000 mg/kg
UTC: Unintentional Trace Contaminant limit	Substances and mixtures: 10,000 mg/kg Articles: 1,500 mg/kg
Sources: Ramboll (2019) and the analysis in RPA (2021)	

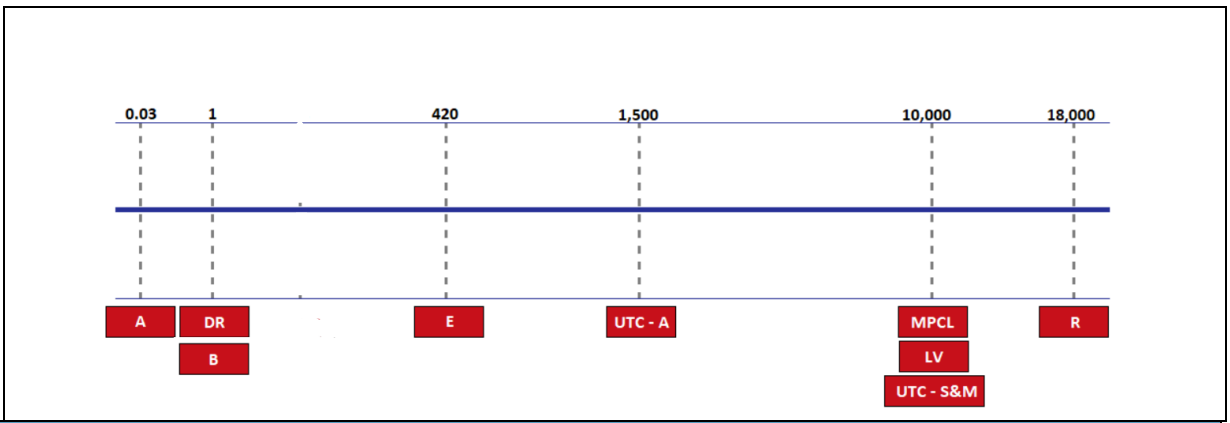


Figure VI-8: Limitation criteria – SCCPs - adapted from RPA (2021)

6.6.6. Perfluorooctanoic acid (PFOA), its salts and PFOA related compounds

Table VI-20 Overview of the relevant waste streams, tonnages, concentrations, disposal and recovery methods, and identifiability					
ID	**Broad use**	**Industry/specific use**	**Waste stream**	**Annual tonnage of PFOA in waste (t/yr)**	**Concentration (µg/kg)**
PFOA and its salts					
A1	Fluoropolymer & fluoroelastomer production	Energy: Cables, coating for weathering, flame and soil resistance; surface treatment agent for conserving landmarks (1)	WEEE or specialist recycling	All fluoropolymers 5 – 23 (1)	No data
A2		Automotive: Insulators, solder sleeves, use in various mechanical components (e.g. semiconductors, wiring, tubing, piping, seals, gaskets, cables) (1)	ELV	All fluoropolymers 5 – 23 (1)	No data
A3		Electronics: Insulators, solder sleeves; vapour phase soldering media (1)	WEEE	All fluoropolymers 5 – 23 (1)	No data
B		Automotive: of O-rings, V-belts and plastic accessories for car interiors; raw material for components such as low-friction bearings & seals, lubricants (1)	ELV		14,900 (1)
H	Semiconductors	Electronics Automotive	ELV WEEE Municipal	<0.05 (2, 3) 0.019 (6)	No data
PFOA-related substances – Sidechain fluorinated polymers					
M	Textiles and leather	Safety clothing	Municipal	0.001 – 0.01 (7) 1,000 (2)	0.078 – 1,710 (1, 4)
N		Outdoor clothing, tents, umbrellas, footwear	Municipal		0.029 – 3,020 (1, 4, 5)
O		Car seats and carpets	ELV	No data	No data
P		Furniture	Municipal	No data	No data
Q		Carpets	Municipal	No data	0.001- 368 (1, 4)

- *Notes and sources:*

1 2018 ECHA Restriction background document https://echa.europa.eu/documents/10162/61e81035-e0c5-44f5-94c5-2f53554255a8
2 Ramboll Environment & Health GmbH (2019): Study to support the Review of Waste Related Issues in Annexes IV and V of Regulation (EC) 850/2004.
https://ec.europa.eu/environment/waste/pdf/Study_POPS_Waste_final.pdf
3 Van der Putte et al, 2010
https://ec.europa.eu/docsroom/documents/13037/attachments/1/translations/en/renditions/pdf
4 Sanchez et al 2019 Pilot screening of perluoroalkyl substances (PFASS) in consumer products from Spanish markets: preliminary results
5 Greenpeace/Brigden 2016 Per' and poly' fluorinated chemicals in branded waterproof clothing, footwear, hiking and camping equipment – Technical report http://www.greenpeace.to/greenpeace/wp-content/uploads/2016/01/Leaving-Traces-Technical-Report.pdf
6 REACH Restriction public consultation 2015
7 During other work by RPA on PFOA, RPA recently found that the calculations of PFOA contained in imported textile were incorrect by an order of six. The study teams believe this should be 1 – 10 kg/year or 0.001 – 0.01 tonnes/year.

Table VI-21: Summary of expected waste management of articles and mixtures containing PFOA (baseline)				
Product	**Landfills**	**Incineration**	**Recycling**	**Re-use**
WEEE	Some	Some	Yes	No
ELV	Limited (municipal)	Some	Yes	Yes
Municipal	Yes	Yes	Some	Limited
Textiles	Yes (municipal)	Yes (municipal)	Limited	Yes
Carpets	Yes (municipal)	Yes (municipal)	Limited	No

Table VI-22 Likelihood of impacts on waste management operators (PFOA)						
Product	**Option 2**		**Option 3**			
			Opt 3 exceeded?	**Impacts**		
	Opt 2 exceeded?	**Impacts on WMOs**		**Recyclers**	**Incinerators**	**Landfills**
Semiconductors in WEEE and ELVs	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
ELV	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
Textiles	Unlikely	Unlikely	Some	Yes (testing)	Unlikely	Yes (testing)
Carpets	Unlikely	Unlikely	Some	Yes (testing)	Unlikely	Unlikely (testing)
Notes: The information for all waste streams is uncertain particularly from textiles and carpet and represent the study team's best estimates						

The limitation criteria that define the range for the Annex IV value are summarised below.

Table VI-23: Limitation criteria - PFOA	
Criterion	*Concentration*
A: Analytical potential	1 mg/kg*
B: Background contamination	0.01 mg/kg*. (based on lowest background value of 0.001 mg/k corrected with an uncertainty factor of 10). 0.061-0.684 µg/kg (sediment) <0.05-1.82 µg/kg (soil)*
DR: Disposal and recovery capabilities	The need for disposal and recovery capabilities cannot be assessed quantitatively due to data gaps
E: Economic feasibility	Economic feasibility cannot be assessed quantitatively due to data gaps
LV: Existing limit value	No Annex IV value is defined. For the related substance PFOS and its derivatives the current Annex IV limit value is 50 mg/kg.
MPCL: Maximum POP Content Limit	No Annex V value is defined. For the related substance PFOS and its derivatives current Annex V limit value is 50 mg/kg.
R : Risk (possible adverse effects on human health and the environment)	-***
UTC: Unintentional Trace Contaminant limit	PFOA – 0.025 mg/kg**** Sum of PFOA related substances 1 mg/kg***
*Ramboll (2019) ** REACH Restriction for PFOA; *** ESWI (2011) proposed a value of 5 mg/kg for PFOS – this is noted here due to the similarity of the different PFAS substances. **** Delegated Regulation (EU) 2020/784	

Note: Although the determination of values lower than 1 mg/kg for PFOA and some of its compounds is possible (see e.g. background concentrations in (B)), a value of 1 mg/kg is defined by Ramboll as a value generally reported by most laboratories.

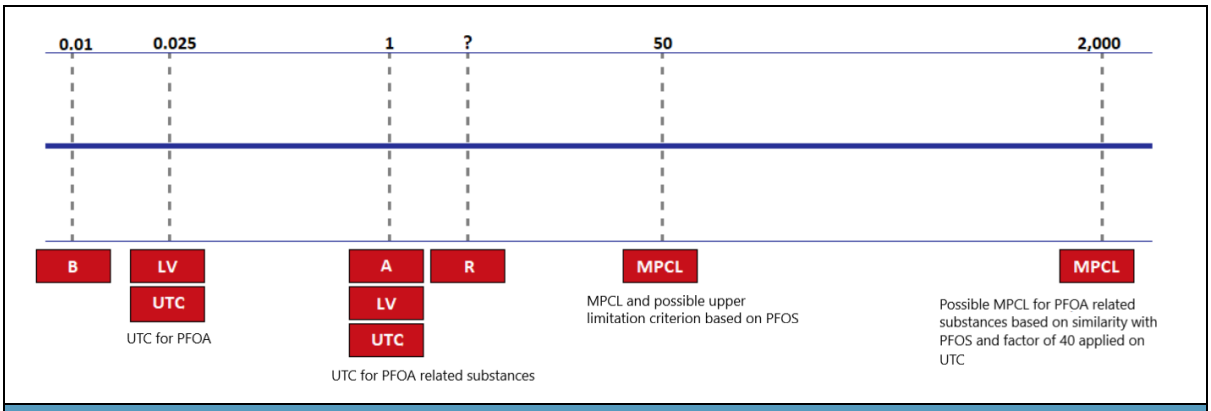


Figure VI-9: Concentration range for Annex IV value for PFOA according to the evaluation of the limitation criteria (adapted from RPA (2021).

6.6.7. Perfluorohexane sulfonic acid (PFHxS), its salts and PFHxS related compounds

Table VI-21: Likelihood of impacts on disposal and recovery methods by waste stream (PFHxS)

Waste stream	Option 2			Option 3		
	Recycling	Landfilling	Incineration	Recycling	Landfilling	Incineration
Textiles	No	No	No	Unlikely (but individual articles may exceed)	Unlikely	Unlikely
Carpets	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
Leather articles	Unlikely	Unknown	Unlikely	Unlikely	Unknown	Unlikely
Semiconductors in WEEE and ELVs	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
Firefighting foams (AFFFs)	No	No	No	No	No	No
Mist suppressants	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
Lubricants	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown

Table VI-22: Summary of expected waste management of articles and mixtures containing PFHxS

Product	Landfills	Incineration	Recycling	Re-use
Textiles (excl. carpets and leather)	46%*	46%*	8%*	Yes (significant)
Carpets	49%	49%	3%	No
Leather articles	Yes	Yes	Limited	Yes
WEEE/ELV	Some	Some	High	Some
AFFFs	No	Yes	No	No
Mist suppressants	Likely low	Likely high	No	No
Lubricants	1%	86%	13%	No

Notes:
* excludes reuse
Some numbers may not total up due to rounding.

The limitation criteria that define the range for the Annex IV value are summarised below.

Table VI-23: Limitation criteria - PFHxS	
Criterion	*Concentration (mg/kg)*
A: Analytical potential	1 mg/kg* Potentially LOQ 0.00006 mg/kg**
B: Background contamination	0.01 mg/kg
DR: Disposal and recovery capabilities	-
E: Economic feasibility	-
LV: Existing limit value	None
MPCL: Maximum POP Content Limit	Potential MPCL could be the same as for PFOS, i.e. PFHxS - 50mg/kg* Sum of PFHxS related substances 2,000 mg/kg*
UTC: Unintentional Trace Contaminant limit	None
* Ramboll (2019) ** See Section 6.3.5	

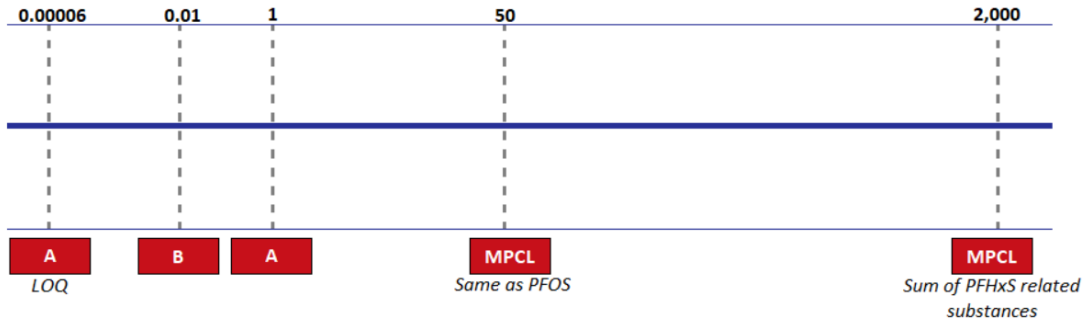


Figure VI-8: Concentration range for Annex VI for PFHxS according to the evaluation of the limitation criteria

Table VI-25: Concentrations of PFHxS in ten samples taken from seven articles of outdoor clothing articles for children[54]		
Type of the product	**Origin**	**PFHxS (mg /kg)**
Coat	China	0
Coat	China	0
Jacket	Unknown	0
Coat	China	0.02
Coat	China	0.3
Trouser	China	2.3
Trousers	China	0.02
Coat	Bangladesh	0.002
Coat	Unknown	0
Jacket	Vietnam	0
Sources: Greenpeace 2013 reported in Annex A of the Norwegian restriction propoal Greenpeace/Brigden 2016 Per' and poly' fluorinated chemicals in branded waterproof clothing, footwear, hiking and camping equipment – Technical report http://www.greenpeace.to/greenpeace/wp-content/uploads/2016/01/Leaving-Traces-Technical-Report.pdf		

[54] ECHA 2017

Table VI-26: Summary of expected waste management of articles and mixtures containing PFHxS				
Product	**Landfills**	**Incineration**	**Recycling**	**Re-use**
Textiles (excl. carpets and leather)	46%*	46%*	8%*	Yes (significant)
Carpets	49%	49%	3%	No
Leather articles	Yes	Yes	Limited	Yes
WEEE/ELV	Some	Some	High	Some
AFFFs	No	Yes	No	No
Mist suppressants	Likely low	Likely high	No	No
Lubricants	1%	86%	13%	No
Notes: * excludes reuse Some numbers may not total up due to rounding.				

Table VI-27: Likelihood of impacts on waste management operators (PFHxS)						
Product	**Option 2**		**Option 3**			
			Option 3 exceeded?	**Impacts on WMOs**		
	Option 2 exceeded?	**Impacts on WMOs**		**Recyclers**	**Incinerators**	**Landfills**
Textiles	No	Unlikely	Unlikely but individual articles Yes	Yes (testing)	Unlikely	Unlikely
Carpets	Unknown	Unknown	Unknown	Unknown (but testing costs likely)	Unknown	Unknown
Leather articles	Unknown	Unlikely	Unknown	Unlikely	Unlikely	Unknown
Semiconductors in WEEE and ELVs	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
Firefighting foams (AFFFs)	No	No	Yes	No	Unlikely	Unlikely
Mist suppressants	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
Lubricants	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown

Table VI-28: Limitation criteria - PFHxS	
Criterion	*Concentration (mg/kg)*
A: Analytical potential	1 mg/kg* Potentially LOQ 0.00006 mg/kg**
B: Background contamination	0.01 mg/kg
DR: Disposal and recovery capabilities	-
E: Economic feasibility	-
LV: Existing limit value	None
MPCL: Maximum POP Content Limit	Potential MPCL could be the same as for PFOS, i.e. PFHxS - 50mg/kg* Sum of PFHxS related substances 2,000 mg/kg*
R : Risk (possible adverse effects on human health and the environment)	-***
UTC: Unintentional Trace Contaminant limit	None
* Ramboll (2019); ** See Section 6.3.5 of RPA report *** ESWI (2011) proposed a value of 5 mg/kg for PFOS – this is noted here due to the similarity of the different PFAS substances.	

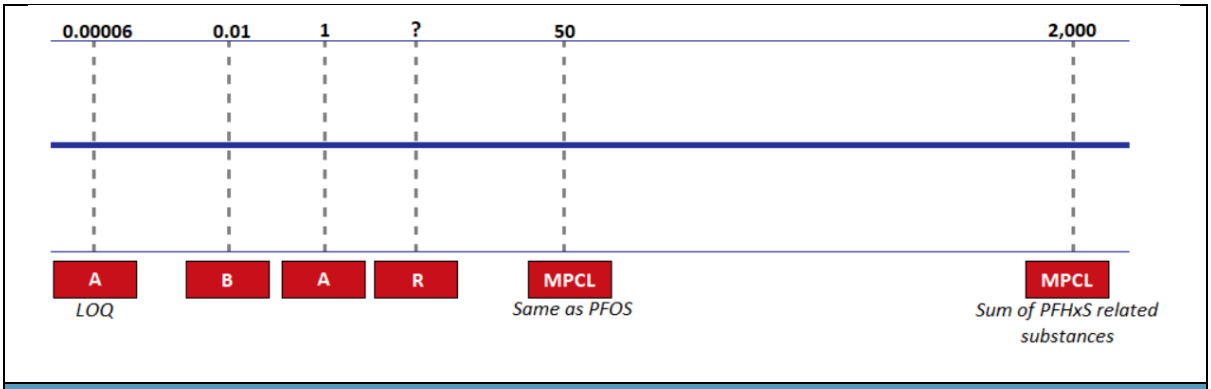


Figure VI-10: Concentration range for an LPCL for PFHxS according to the evaluation of the limitation criteria

6.6.8. Pentachlorophenol and its salts and esters (PCP)

Table VI-29: Relevant products, average lifetimes, expected trends

Article	Waste stream	Average product lifetime	End of use in the EU	Future trends	Particularly relevant until the end of …
Textiles	Separate collection MSW	5-10 years	2008	Material resale/recycle, landfilling, incineration	2022
Wood products	Wood	25 years	2008	Incineration	2032

Table VI-30: Significant impacts for consideration under the different options

Year	PCP in wood		Wood containing PCP		PCPL		Textiles containing PCPL	
	Annual disposal amount [t/y]	Future disposal amount [t]	Annual disposal amount [t/y]	Future disposal amount [t]	Annual disposal amount [t/y]	Future disposal amount [t]	Annual disposal amount [t/y]	Future disposal amount [t]
2018	155	766	248,000	1,225,600	12	16	480	640
2019	138	628	220,800	1,004,800	8	7	320	280
2020	121	507	193,600	811,200	5	2	200	80
2021	106	401	169,600	641,600	2	0	80	0
2022	91	310	145,600	496,000	0	0	0	0
2023	77	233	123,200	372,800	0	0	0	0
2024	64	169	102,400	270,400	0	0	0	0
2025	51	119	81,600	190,400	0	0	0	0
2026	40	79	64,000	126,400	0	0	0	0
2027	30	49	48,000	78,400	0	0	0	0
2028	21	28	33,600	44,800	0	0	0	0
2029	14	14	22,400	22,400	0	0	0	0
2030	8	6	12,800	9,600	0	0	0	0
2031	4	1	6,400	1,600	0	0	0	0
2032	1	0	1,600	-	0	0	0	0
2033	0	0	-	-	0	0	0	0

Elaborated on ESWI (2011) assumptions

The limitation criteria that define the range for the Annex IV value are summarised below.

Table VI-31: Limitation criteria - PCPs	
Criterion	*Concentration (mg PCPs/kg)*
A: Analytical potential	0.1 mg/kg
B: Background contamination	1 mg/kg
DR: Disposal and recovery capabilities	Lower than 100 mg/kg
E: Economic feasibility	Lower than 100 mg/kg
LV: Existing limit value	Currently none (listed by Regulation (EU) 2019/636 but not adopted in recast POP Regulation: 100 mg/kg)
MPCL: Maximum POP Content Limit	Currently none (listed by Regulation (EU) 2019/636 but not adopted in recast POP Regulation: 1,000 mg/kg)
R : Risk (possible adverse effects on human health and the environment)	**100 mg/kg** (based on low range of PNEC values for soil/sediment). See table IV-2 of section 4.3 of Annex IV. 5,000 mg/kg (based on ASTDR MRL)
UTC: Unintentional Trace Contaminant limit	5 mg/kg
Sources: ESWI (2011) and the analysis in RPA (2021).	

It is noted that under the previous POPs Regulation (Regulation (EC) No 850/2004), an LPCL of 100 mg/kg and MPCL of 1,000 mg/kg were listed by Regulation (EU) 2019/636 but these were not adopted in recast POP Regulation (Regulation (EU) 2019/1021).

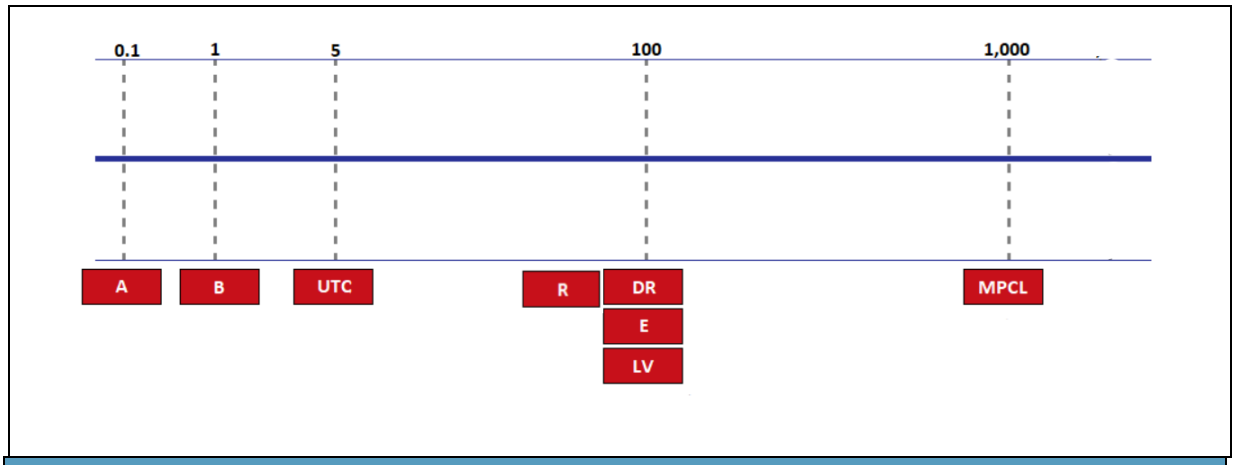


Figure VI-11: Limitation criteria – PCPs – adapted from RPA (2021)

6.6.9. Dicofol

Table VI-32: Dicofol production and important milestones in the EU [Ramboll (2019)].

Year	Dicofol production in [t]	Additional information / Milestones
2000 – 2012	1,745 (accumulated)	Accumulated production in Europe (from 2000-2012)
2000	1,500	Produced in Spain (one production facility)
2006	90	Produced in Spain (one production facility)
2006 (2008/09)	-	Production in Spain ceased after 2006 (possibly around 2008/09)
2009 and 2010	-	All existing authorizations for dicofol in plant protection products withdrawn before 30 March 2009 and national registration not possible. Transitional periods granted expired by 30 March 2010.

The limitation criteria that define the range for the Annex IV value are summarised below.

Table VI-33: Limitation criteria - Dicofol

Criterion	Concentration (mg PCPs/kg)
A: Analytical potential	0.03 mg/kg
B: Background contamination	3 mg/kg
DR: Disposal and recovery capabilities	Not applicable. No wastes identified.
E: Economic feasibility	Not applicable. No wastes identified.
LV: Existing limit value	Currently none
R : Possible adverse effects on human health and the environment	200 mg/kg Based on EQS for sediment. See table IV-2.
MPCL: Maximum POP Content Limit	Currently none. DDT and other organochlorine pesticides have an Annex V limit value of 5000 mg/kg.
Source: Ramboll (2019)	

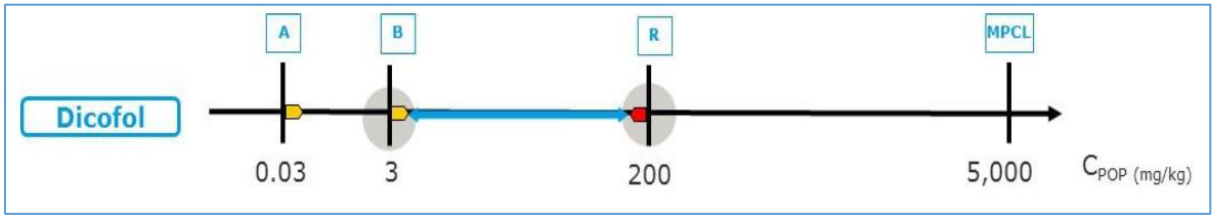


Figure VI-12: Limitation criteria for dicofol. Ramboll (2019).