VinylPlus® comments on the Ramboll report (2022) entitled "The use of PVC in the context of a non-toxic environment" [1]

EXECUTIVE SUMMARY

Introduction

VinylPlus would like to provide clarifications and corrections on specific elements of the Ramboll report (2022) so as to ensure there is a factually accurate basis for a constructive discussion on PVC with the European Commission and other recipients.

First and foremost, we note with concern the explicit inclusion of "phase-out scenarios" at the outset in the European Commission tender for this study. This prejudges the scientific analysis, already anticipating a specific result and directing the consultant to a biased approach.

Although our comments focus on highlighting identified gaps and issues with the report, we would like also to note some of the report's conclusions, which accurately reflect the situation, in particular with regards to recycling. In particular, we welcome that the report acknowledges ECHA's conclusions that the recycling of PVC containing lead is preferable to landfilling or incineration, as well as the fact that PVC alternatives are facing the same obstacles with regards to the management of legacy additives.

We have been addressing proactively many of the concerns raised by the report (e.g. regarding the presence of legacy additives in PVC recyclates) under our VinylPlus programme during the period 2010-2020,[2] and have since further raised our ambitions with the VinylPlus 2030 Commitment[3] and its Additive Sustainability Footprint®[4] (ASF) methodology.

In order to enable a constructive discussion, we have developed an overview of our key comments and concerns.

1. Report methodology and its unequal application

Despite the report's stated objective to analyse "alternatives to PVC applications, *considering relevant life cycle assessments aspects* and market availability" [our emphasis], such LCA aspects are largely not covered and the market figures used are open to debate. Alternative materials are often cited with little to no consideration for technical drawbacks (which would occur in most applications), additional costs, and end-of-life management. Additives in most alternative materials are comparable – if not the same – to additives used in PVC, and may be subject to future regulatory action. Only limited information has been gathered for some alternatives to these additives (e.g., phthalate free plasticizers, additives in bioplastics). The report itself points to the fact that the range of products accessible in specific applications may decline if PVC is phased out, while the cost of alternatives may grow. On this note, the fact that PVC is the most used polymer in medical equipment is not without rational. It is so because of its unparalleled technical performance, accounting for 82% of the market for medical tubing in Europe.[5]

[1] The report published by EU Commission ref ENV/2020/MVP/029, has been prepared by Ramboll and Logika Noise Air Quality consultants.
[2] https://www.vinylplus.eu/resources/new-vinylplus-progress-report-2021/
[3] VinylPlus 2030
[4] Additive Sustainability Footprint®
[5] https://pvcmed.org/healthcare/facts-figures/

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The report fails thus to show how switching to alternatives would constitute an improvement compared to PVC products, and instead focuses mainly on their market availability. Even for market availability some concerns could be raised as the statements in this regard, as the elements found in the report seem to be solely based on information provided by manufacturers of PVC-free products with an obvious commercial interest. Moreover, the report does not identify possibly affected production lines for specific applications and hence fails to outline a feasible roadmap for the adaptation of supply chains to alternatives. As such, any conclusions pertaining to socio-economic effects for consumers and downstream users are by definition inaccurate.

In this sense, the report falls well short of previous reports with similar scopes and purposes, such as the report entitled *"Life Cycle Assessment of PVC and of principal competing materials",*[6] commissioned in 2004 by the European Commission.

Furthermore, by focusing in isolation on the environmental and health effects associated with a single material, the report could be misleading. For example, the authors link dioxin emissions to the presence and use of PVC. However, dioxin emissions related to PVC manufacture and disposal have declined dramatically in the last decades, a fact that is not mentioned in the report and if PVC were phased out, it would be almost impossible to measure a decline in the overall dioxin emission into the environment.[7]

Finally, the economic 'feasibility' should be based on the Total Cost of Ownership approach (costs of purchase, installation, maintenance and end-of-life management) rather than purchase prices only.[8] In essence, TCO considers the intrinsic costs of a product throughout its life cycle (i.e., introduction, growth, maturity, decline). PVC delivers significant cost benefits, not just in terms of its low initial purchase price, but also in terms of its low cost of ownership over the whole product lifecycle and across the supply chain. The cost advantages of PVC and its potential to drive savings should therefore not be overlooked.[9]

2. Most issues raised by the authors are not specific to PVC

Many issues of concern raised are not specific to PVC (e.g. use of unwanted additives, waste not correctly separated, incineration, landfilling). For example, legacy additives (present in old PVC articles still used today, thanks to PVC longevity) may be present in alternative (plastics as well as non-plastic) materials. The PVC industry has demonstrated[10] how these additives can be safely managed when the recyclates containing them are re-used within new articles. Additionally, the report is not transparent about the fact that many alternatives – and other materials – present the same issues. The report may give unsuspecting readers the false impression that by phasing-out PVC, issues of concern would be addressed.

3. Lack of acknowledgment of industry action on numerous phased-out additives

The report does not make a distinction between former and current uses of additives. The result is that many of the overall concerns expressed in the report relate to additives which have already long been phased out by the industry – and are often already subject to restrictions under the REACH Regulation. Consequently, the report's far-reaching recommendations are not based on the current situation of European PVC products'

[6] Life Cycle Assessment of PVC and of principal competing materials Commissioned by the European Commission, April 2004 Authors: Project Coordination Dr. Martin Baitz Mr. Johannes Kreißig Ms. Eloise Byrne Ms. Cecillia Makishi Mr. Thilo Kupfer Dr. Niels Frees Dr. Niki Bey Mr. Morten Söes Hansen Ms. Annegrethe Hansen Dr. Teresa Bosch Dr. Veronica Borghi Ms. Jenna Watson Ms. Mar Miranda (Link).
[7] https://inis.iaea.org/search/search.aspx?orig_q=RN:42047414
[8] https://electricalengineeringmagazine.co.uk/rd-innovation-and-sustainability-the-new-deal-of-the-pvc-cables-sector/
[9] http://www.pvcconstruct.org/en/p/pvc-tco
[10] See for example https://www.stabilisers.eu/lead-replacement/

manufacturing – nor are they relevant for the consideration of PVC's impact on PVC for human health and the environment.

The report further states that "the vast majority of PVC additives are not covalently bound to the polymer and as such can migrate out of the polymer matrix." However, in the large majority of cases, the migration of substances from the polymer matrix is very low, if not negligible (see references in p.4 of this document, under the Annex). This statement, together with a lack of sufficient information on migration of substances in concrete and comparative terms, leads to a misleading conclusion on the behavior of PVC additives. The legacy additives – as all additives not covalently bound to the polymer matrix - are embedded into the PVC matrix, ensuring that they remain safely within the product.

Morevover, similarly to other concerns raised in the report, the migration of additives is not an issue limited to PVC. Finally, the report does not apply the same level of analysis to alternative materials, potentially leading readers to the erroneous conclusion that these alternatives would not present similar challenges.

4. VinylPlus sustainability programme is only scarcely mentioned

A noteworthy and unfortunate shortcoming of the report is that the sustainability programme developed and implemented by the European PVC industry over the last twenty years is only mentioned sporadically, while references to VinylPlus recycling figures are also sparse. Only in a few instances is VinylPlus mentioned as a reference to recycling figures.

This is all the more puzzling when considering the fact that the European Commission participates in an independent committee[11], which twice per year since 2011 oversees and monitors the environmental progress being made by the European PVC industry.

Importantly, the VinylPlus Additive Sustainability Footprint®[12] (ASF) methodology is not presented as a tool for the assessment of currently used additives. Given that the Ramboll report focuses on the assessment of additives and on the possibility that additives in plastics allowed today might be restricted tomorrow, a closer look at the ASF tool would have provided useful insights to the authors when assessing the sustainability of additives.

5. The report is consistently negative towards PVC

The report hardly makes any reference to the positive environmental contributions of PVC, e.g,. PVC's lower reliance on fossil fuels when compared to other polymers (57% of PVC is derived from salt, a resource much more sustainable than the hydrocarbons from which most competing polymers are entirely sourced) or its lower carbon footprint when compared to other materials such as metal or glass. Unique PVC characteristics such as its long lifespan are also not adequately reflected in the report.

Furthermore, the report fails to mention the versatility of PVC, which, through the use of different additives, can be shaped into a wide range of products meeting end users' specific needs. This is a considerable advantage as it allows for the development of many innovative PVC applications. Finally, the report also fails to mention that PVC is possibly the only polymer that can be recycled at least 10 times without loss of characteristics and performance.[13]

[11] VinylPlus Monitoring Committee
[12] https://www.vinylplus.eu/sustainability/our-contribution-to-sustainability/additive-sustainability-footprint/
[13] VYNOVA blog "Vynova Research Highlights Impressive Longevity of PVC Pipes" posted by Jonathan Stewart on 30 April 2019.

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ANNEXES

Comments per chapter including factual errors. A short summary is provided ahead of each chapter.

CHAPTER 2 – THE CHEMISTRY OF PVC

Summary of comments

Most of the information regarding stabilisers and plasticisers is inaccurate or outdated, especially regarding the stabilisers currently used, and the risks of additives' migration.

The report states that "the vast majority of PVC additives are not covalently bound to the polymer and as such can migrate out of the polymer matrix". This statement is correct insofar as there is no covalent bond between the additives and the PVC, but weaker liaison forces do exist (see further below within the comments on chapter 2) and in the large majority of cases, the migration of substances from the polymer matrix is very low, if not negligible. For example, the diffusion coefficient of lead in rigid PVC at 30 °C was found to be on the order of 0.6 to $3*10^{-17}$ cm^2/s[i].[14] As a rule, the legacy additives are embedded into the PVC matrix, ensuring that they remain safely within the product. Different studies from Fabes,[15] a well-known testing institute active especially in food contact materials, have shown that the migration of additives in PVC is very low . Further, plasticisers quickly degrade in landfills.[16]

Regarding legacy additives (present in old PVC articles still used today, thanks to PVC longevity), these may be present in alternative (plastics as well as non-plastic) materials. The PVC industry has demonstrated[17] how these additives can be safely managed when the recyclates containing them are re-used within new articles.

Most of the information regarding stabilisers and plasticisers in the report is not accurate and in many cases is outdated. Some examples:

- Page 27: the authors are referring to unstabilised PVC and its potential release of HCl at low temperatures but it is meaningless since unstabilised PVC is never used on its own.
- In Table 2.4.1 the information is outdated. The main stabilizers used in EU today are calcium zinc and organic-based. The use of lead-based stabiliers has been entirely phased out by the EU PVC industry since 2016.[18] Statistics of the different types of stabilizers are available, for example from the annual Progress Reports of VinylPlus.[19]
- In Table 2.4.1: Acid scavengers are just one category of stabilisers. The report mistakenly assumes that they are different entities.
- Page 25: the report states that "Some of the additives, especially plasticisers are substances of concern and have hazardous properties". This is an inappropriate generalization because not all plasticisers are hazardous.[20]
- Page 29: the report states that because of its polar nature caused by the chlorine, its electrical insulating property [of PVC] is inferior to PE and PP. Each polymer type has its advantages and disadvantages. The better flexibility of PVC and the better fire properties are much appreciated in the cable market.

[14] Peter Mercea , Christoph Losher,Marcus Petrasch,Valer Tos 'Migration of Stabilizers and Plasticizer From Recycled Polyvinylchloride" in JOURNAL OF VINYL & ADDITIVE TECHNOLOGY—2017, page 7.
[15] Peter Mercea, Christoph Losher,Marcus Petrasch,Valer Tos "Migration of Stabilizers and Plasticizer From Recycled Polyvinylchloride" in JOURNAL OF VINYL & ADDITIVE TECHNOLOGY—2017, pages 1-13.
[16] The Behaviour of PVC in Landfill, report for the European Commission by ARGUS in association with University Rostock-Prof. Spillmann, final report February 2000, page 26 and following ones.
[17] See for example https://www.stabilisers.eu/lead-replacement/
[18] See for example https://www.stabilisers.eu/lead-replacement/
[19] https://www.vinylplus.eu/resources/
[20] https://www.europeanplasticisers.eu/mediaroom/dinp-echas-rac-final-opinion-no-classification-warranted/

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- Page 33: the report states that "In recent years many of these [plasticisers] have been found to have adverse effects on humans and the environment resulting in a shift towards other phthalate-based plasticisers (that are less hazardous) and non-phthalate plasticisers". The other phthalate plasticizers like DINP, DPHP and DIDP used are not hazardous (or less hazardous), as demonstrated by their lack of hazard classification under the CLP Regulation.
- Page 33: it has to be noted that MCCPs are **not** typical alternatives to phthalates.[21]
- Page 34, the report states "Most of PVC stabilisers identified are based on inorganic salts such as cadmium and lead, however, there are also tin and organophosphorus based heat stabilisers". This is not correct: the stabilizers in EU are today mainly based on Ca/Zn salts or they are organic-based. There are statistics to show the evolution of the stabilizer families.[22]
- Page 37, the report states that "certain additives, may pose risks of harm to human health as most of these components are not covalently bound to the polymer matrix. However, plasticisers are bound by e.g. van der Waals forces and do not evaporate or migrate easily. Any potential migration depends on the contact material.[23]

CHAPTER 3 - GENERAL MARKET ANALYSIS

Summary of comments on Chapter 3

Some figures are incorrect and convey misleading messages, for example regarding the amount of generated PVC waste (overestimated) or the amount of PVC products manufactured in the EU (underestimated). The price information is incomplete, failing to indicate whether it relates to PVC resin, PVC compound or PVC products.

- Page 43: "Up to 4.1 million tonnes (1999) of PVC waste is generated in the EU annually". This is certainly excessive and possibly based on less reliable information from the past. According to the market analysis consultant Conversio, in 2020 the amount of " total generated PVC waste" in the EU was 2.92 million tonnes, of which 2.435 Mt of post-consumer waste.[24]
- Page 52: "The tonnage totals are 3,380,900 tonnes of PVC products manufactured within the EU". This is significantly underestimated. Knowing that in 2019 PVC use by converters was more than 5 million tonnes,[25] and assuming additives represent about 20 % of resin overall, the EU output of PVC products will likely amount to 6 million tonnes approximately.
- Page: 60: Lead stabilisers are mentioned in Table 3-10. As already stressed before, the members of VinylPlus stopped using or selling lead-based stabilisers in the EU in 2015. In fact their use had been declining already since 2000.
- Page 60: Azodicarbonamide is mentioned as a flame retardant in Table 3-10. ADCA is a blowing agent widely used for producing foamed applications in a large range of polymers; it is not specific to PVC, and it is not a flame retardant. Moreover, it is not dangerous in terms of migration because it is broken down during the foaming process, releasing only nitrogen.
- Page 61: Brominated Flame Retardant (FR), DecaBDE, is mentioned in Table 3-11. These FRs are not used in PVC, as there is enough chlorine in PVC to provide flame retardancy.
- Page 61: BPA is mentioned as plasticiser in Table 3-11. BPA is an antioxidant, not a plasticiser.
- Page 61: Calcium oxide is mentioned as a stabiliser in Table 3-11. Calcium carbonate is often present as a filler, but we are not aware of calcium oxide being used in PVC, for any purpose.

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[21] Polcher et al. 2020; Wiesinger, Wang, and Hellweg 2021.
[22] See for examples the Progress Reports of VinylPlus, https://www.vinylplus.eu/resources/?_sft_resources_categories=progress-reports .
[23] References 14 and 15 in this report.
[24] Report "Post-consumer PVC waste in EU 28+2 countries 2016" by CONVERSIO Market and Strategy, available on demand.
[25] Plastics – the Facts 2020, see https://plasticseurope.org/knowledge-hub/plastics-the-facts-2020/

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- Page 76: It is not clear whether indicated prices refer to PVC resin or to PVC compounded with additives. For example: "China had the lowest trading price in 2017 at 2,031 €/tonne. Germany's price per tonne was middling compared to other international competitors, at 2,360 €/tonne. India and Japan sold on average at 2,617 and 2,814 €/tonne respectively". These prices are well above the around 1000 EUR/t usual price of PVC resin, and hence almost certainly refer to compounded PVC and/or the first transformation step (e.g. tubes).

CHAPTER 4 - GENERAL FINDINGS ON MANAGEMENT OF PVC WASTE

Summary of comments on Chapter 4

Whilst the report acknowledges the benefits of all types of recycling, including open loop recycling, it does not mention the fact that for PVC, the amount of recycled PVC has been increasing steadily over the past 20 years, and the fact that for most other polymers recycling levels are still as if not more limited. As in other chapters, potential migration of additives is repeatedly highlighted, without taking into account that many additives with hazardous characteristics have been substituted, that migration of additives out of rigid PVC is actually very low and that plasticisers, if any, leached out of landfilled flexible PVC biodegrade quickly.

- The still relatively limited proportion of PVC waste being recycled is highlighted several times, but PVC is far from being the only polymer in this respect. Moreover, starting from almost zero recycling twenty years ago, the amounts of recycled PVC, as well as the proportion relative to rising waste production, have been increasing steadily thanks to a concerted effort of industry stakeholders.[26] This steady year by year increasing trend was only interrupted in 2020, due to the pandemic.
- As in other chapters, potential migration of additives is repeatedly underlined. This comment fails to take into account the following facts:
  - There is a big difference in the migration rates of additives between flexible and rigid PVC. Flexible PVC contains plasticisers which loosen the interaction between polymer chains and hence increase diffusion speed through the polymer matrix. Flexible PVC behaves in this aspect like other flexible polymers, like e.g. polyethylene. Diffusion of substances in rigid PVC is much slower, as it is in other rigid plastics like PET. Studies by German consultant FABES submitted to ECHA demonstrate this fact, as mentioned higher up.[27]
  - Plasticisers leaching out of landfilled PVC biodegrade quickly, and hence disappear to a large extent before entering the soil.[28] Moreover, in properly managed landfills, the soil shall be covered by a protective lining.
  - Last but not least, additives of concern have been substituted, voluntarily, in response to customers' demand. The stabilisers based on cadmium and lead are no longer used in Europe since 2001 and 2015, respectively. The low molecular weight phthalates have been replaced by high molecular weight ones, which are not classified as hazardous, and are widely available. Alternative non-phthalate plasticisers also are available and widely used.
  - In numerous uses, the potential release of additives by PVC products is assessed, measured and subject to robust evaluation. Examples can be easily found in the cables and flooring sectors and show that any potential for plasticiser release is both low and adesuately controlled.

CHAPTER 5 - RECYCLING OF PVC WASTE

Summary of comments on Chapter 5

[26] https://vinylplus.eu/wp-content/uploads/2021/06/VinylPlus-Progress-Report-2021_WEB_sp-1.pdf
[27] References 14 and 15 in this report.
[28] Reference 16 in this report.

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The report cites ECHA's conclusion that recycling of PVC containing lead is preferable to incineration or landfilling. However, the report's repeated considerations on additives' migration at best overshadow the proven safe recycling record of PVC, and at worst are exaggerated. The concerns about dioxin emissions from recycling are unfounded.

Many of the comments made for Chapter 4 are also relevant for Chapter 5. Additionally:

- It is misleading to focus on the environmental and health effects associated with a single material. If PVC were phased out it would be almost impossible to measure a decline in the overall dioxin emission into the environment. Dioxin emissions related to PVC manufacture and disposal have declined dramatically during the last decades.[29] This is not mentioned in the report.
- The statement on page 100 "It is important to note that the contamination of waste streams with impurities is a problem that is not limited to these examples or the recycling of PVC as such but is a general challenge for all mechanical recycling" is a fundamental point which lacks visibility in the report and should be included in the summary and/or conclusion.
- Given its central relevance, the statement on page 131 "It is also important to note that, within the context of the proposed REACH restriction on lead in PVC, ECHA has considered that recycling of PVC recyclate containing lead in applications such as three-layer sewer pipes or as middle-layer in window frames is preferable to incineration or landfilling" should also be included in the summary and/or conclusion of the report.
- Several other statements are, by contrast, questionable, such as:
  - Page 90: "Available information suggests that, in practice, the presence of hazardous substances (e.g. lead or DEHP) and their potential for migration from the plastic matrix is not sufficiently taken into consideration for the correct classification of PVC". This is an unfounded allegation in the absence of reliable sources. The CLP Regulation gives precedence to classification based on actual risk data over classification based on the presence of hazardous substances, and the Waste Framework Directive follows the same logic.
  - Page 102: "it is important to note that currently various additives with hazardous characteristics are still used in PVC and are not subject to prohibitions or restrictions. (…) such additives could lead to risks for human health and the environment if they are emitted from the PVC via migration and could be subject to future restrictions". This is unsubstantiated. As cadmium and lead stabilisers have been substituted, as well as DEHP in most applications, these facts should be mentioned so as to allow readers to decide whether the risk, if any, is indeed an obstacle for recycling. Furthermore, migration is well understood and not a concern as demonstrated previously.
  - Page 104: The statement: "economically feasible expansion of recycling operations to other PVC waste sources (…) may be limited due to technical difficulties (e.g. collection and sorting) or competition from cheaper waste recovery and disposal options" is correct, but incomplete. Recycling is also limited by businesses' reluctance to invest, in view of the uncertain regulatory situation about additives.
  - Page 109: The statement "Moulding and extrusion which are key stages in plastic recycling are normally operated at 200–300 °C which can cause a release of certain legacy substances (e.g. cadmium, lead) and several hazardous substances (e.g. toxic metals…)" in Table 5-9 is inaccurate and incomplete. Moulding and extrusion of PVC (as well as any other PVC conversion into products) is operated at or below 200 °C, to prevent PVC degradation as well as dioxin formation. Moreover, it is not clear which "toxic metals" are meant, in addition to cadmium and lead. Such allegations should be substantiated or deleted.
  - Page 110: "Flooring and cable waste from post-consumer collection is recycled as well, but mainly end up in products like traffic products for road traffic safety. This kind of recycling can be seen as

[29] https://inis.iaea.org/search/search.aspx?orig_q=RN:42047414

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downcycling as it is very likely that such will be transferred to energy recovery after their use". This reflects a frequent misunderstanding and contradicts the statement in Chapter 4 "In open-loop recycling, the recycled material is used to produce a different type of product than the product the material was recovered from. This does not imply downcycling. The new product can be of the same value". Such recycling still avoids using virgin resin, and hence saves resources. These products, if made from virgin resin, would have the same likelihood to end up in energy recovery installations.

- Page 114: The allegation about chemical recycling that « dioxin and dioxin-like PCBs are produced (at any operating condition)". This is inaccurate. Dioxins are not produced at low temperature, and, more importantly, are destroyed at higher temperatures.[30]
- Page 101: "Flooring in general seems to be a problematic product group for mechanical recycling (Focus Group)". This is neither backed up by any evidence nor does it take into account already existing end-of-life solutions. In fact, flooring is mechanically recycled and glue and concrete particles are not a hinderance to the process as such.[31] [32]
- Page 135: "In total, the amount of recyclate of the total PVC production in Europe was very low (1,3%)." This lacks a reference year and indeed looks like a very outdated figure. Compared to the about 6-7 Mt of EU production of PVC products, the more than 700 kt recycled by VinylPlus represents at least 10 %. In any case this should be compared to total PVC waste generated in Europe and not to virgin PVC volumes in order to take account of the longevity of the majority of PVC products.

CHAPTER 6 – OTHER RECOVERY, DISPOSAL AND SHIPMENT OF PVC

<u>Summary of comments on Chapter 6</u>

The concern about uncontrolled burning and related dioxin emissions must be acknowledged, but it needs to be stressed that bans of such illegal practices should be enforced, and that these concerns are relevant for all kinds of waste, including those arising from competing materials. Regarding dioxin formation during incineration, the report fails to acknowledge the Commissions's statement that "at the current levels of chlorine in municipal waste, there does not seem to be a direct quantitative relationship between chlorine content and dioxin formation"[33] and hence that substituting PVC would not solve the issue.

Lack of reference to new EU-funded technological breakthrough

The formation of neutralization residues during incineration of PVC waste is an issue which gets a lot of attention in the report. The residues must be disposed of as hazardous waste and it is therefore associated with risks. As almost half of the PVC waste ends up in incineration plants this issue cannot be ignored. What the report on the other hand does not give as much attention is the fact that a technological breakthrough in solving this issue is imminent.

The Halosep process is only briefly mentioned in the annex of the report i.e., that Halosep project phase ended on 31.12 2012 and that the technology is not commercially available. This is incorrect as indicated above. This process, which has been developed in Denmark and financially supported by the EU Life Program with €2.2 million, could be a solution.[34] A full-scale demonstration plant has recently been built in an existing incineration

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[30] https://www.vinylplus.eu/resources/pvc-production-and-waste-incineration-dioxins-eliminated-pvc-production-and-waste-incineration-dioxins-eliminated/
[31] Acceptance conditions | AGPR - Arbeitsgemeinschaft PVC-Bodenbelag Recycling
[32] https://professionals.tarkett.com/en_EU/node/recycling-used-homogeneous-flooring-13311
[33] Commission Green Paper "The environmental issues of PVC" (2000).
[34] https://www.lifehalosep.eu/

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plant near Copenhagen. The Halosep technology turns the mentioned hazardous waste into safe products. The end products are metals for reuse in new products, specifically salt for de-icing purposes and non-hazardous ash to be used in concrete production.

It also should be mentioned that it is not only PVC waste that contribute to the formation of neutralization residues. Many diverse types of waste contribute. The Danish EPA has estimated that the PVC waste is responsible for 5% of these residues.[35] This information cannot be found in the Ramboll-report.

The report highlights concerns about uncontrolled burning of PVC especially in relation to landfill fires as well as accidental fires in houses and factories as well as issues on backyard and cable burning with concerns expressed regarding dioxin emissions. These are illegal practices and unfair criticism voiced at PVC. There are also some positive reflections regarding house fires in which the authors refer to toxicity tests showing that PVC decomposition products are not as toxic as other common building materials. It is an established fact that the main concern for human fatalities associated with fires is carbon monoxide poisoning – released from all forms of carbon sources.

Some parts of Chapter 6 have old references and not up to date information

- Table 5-14 is based on the oldest available prediction from 2013
- On page 155, Table 6-3: regarding PVC in post-consumer electro and electronic products it is not clear why there is no reference to VinylPlus cable recycling volumes– the VinylPlus reported recycling figures are regularly reported and they are audited.
- On page 169, the authors are reporting associated economic aspects for waste, but the references are from 2003 which is deemed not to be relevant in 2022

The statement in the key messages: "the input of PVC increases the risks of dioxin and furan emissions during transient phases and if optimal operation conditions are not met" needs more explanation.[36] The amount of dioxins generated during waste incineration is not proportional to the amount of chlorine present. Studies have shown that if the chlorine level exceeds a (low, possibly below 0.1 %) threshold, there is no statistically significant correlation between the chlorine level in waste and the amount of dioxins produced. These views on the lack of relationship between chlorine content and dioxin formation are based on more than ten in-depth studies carried out in various parts of the world. This led the EU Commission to write "It has been suggested that the reduction of the chlorine content in the waste can contribute to the reduction of dioxin formation, even though the actual mechanism is not fully understood. The influence on the reduction is also expected to be a second or third order relationship. It is most likely that the main incineration parameters, such as the temperature and the oxygen concentration, have a major influence on the dioxin formation. The Green Paper states further that "at the current levels of chlorine in municipal waste, there does not seem to be a direct quantitative relationship between chlorine content and dioxin formation."[37]

We acknowledge the sentence at the end of key messages: "... illegal waste treatment (especially illegal disposal and incineration under uncontrolled conditions) remains a problem in EU Member States and countries outside the EU". We wish however to comment that actions should focus on combatting such illegal practices, rather than substituting PVC, because even if PVC would be fully substituted there would still be enough halogens in wastes, be it from food or from flame-retardants in other plastics, to generate dioxins during illegal burning.

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[35] 978-87-7038-000-3.pdf (mst.dk)

[36] https://ec.europa.eu/environment/archives/air/stationary/wid/legislation.htm

[37] Green Paper on the Environmental Issues of PVC (July 2000).

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CHAPTER 7 - ANALYSIS OF ALTERNATIVES

Summary of comments of Chapter 7

Despite an attempt to mention some negative aspects of competing materials and positive aspects of PVC, the chapter is clearly written with the intention to show that PVC can easily be substituted in all its applications, at an acceptable cost. These hypotheses have been repeated numerous times in the report but not one of them has been tested and proven with evidence. This biased approach witnesses methodological flaws, such as e.g. citing some outdated sources and failing to assess their credibility, reliability and accuracy, and, when comparing materials, relying on different sources with different methodologies, scopes and reference periods. Also, economic 'feasibility' focuses on purchase prices without properly taking into account installation, maintenance and end-of-life management. A proper definition/criteria set of "economic feasibility" is lacking. "Commercial availability" is covered without regard to the variety of different uses with different requirements encompassed in any given of the considered main applications and the possible impact of substituting PVC in large volume applications on the availability and cost of alternative materials. Lastly, it has to be pointed out that the overall biased premise is reflected in choices of colours displayed in the overall comparison tables, most egregiously in colouring missing information for competing materials green.

Although there are some rational statements, for example "The presence of additives in alternative materials presents the same obstacles to recycling currently observed with PVC", this Chapter is written with the clear intention to show that PVC can easily be substituted in all its applications, at an acceptable cost. This is a biased approach:

- The numerous sources cited are a mixture of some reliable ones, or at least articles in (probably peer-reviewed) publications, but many are from NGOs which are well-known for their principal opposition to PVC (e.g. Center for Health, Environment and Justice, Greenpeace) or might even be commercial 'literature' from companies selling products made from competing materials (e.g. page 264). This lack of assessment of the reliability and credibility of sources is a major methodology flaw. Some allegations are clearly wrong, and originate from unreliable sources, for example quoting Center for Health, Environment and Justice about PVC packaging being banned "in a number of individual countries" (page 248).
- Additionally, when comparing materials, using different information sources is very questionable because of different methodologies, scopes and periods of reference in these sources. Categorization of applications and corresponding uses of recyclate are defined differently and hence not comparable. For example: the study consistently speaks about "window profiles" and compares these to other window materials, classified for indoor use. In Europe 40% of profiles are construction profiles other than windows (such as external cladding, decking, roller shutters), for outdoor use.[38]
- Many sources are rather old, and hence obsolete with respect to PVC additives, not taking into account how the currently used additives are different from the past, due to industry's voluntary commitments as well as regulations and market trends.
- Page 202: the claim that polybutene (more specifically polybutene-1) would be an alternative material to PVC in pipes is not realistic. Polybutene is a specialty plastic, 3 to 4 times more expensive than PVC and only available in very limited quantities (global capacity is of the order of 100 kt, with only about 4 suppliers). Where rigidity is required, wall thickness would have to be much higher than for PVC, leading to prohibitive cost.
- Sometimes, sources seem to have been mixed up. On p.222 a paper on PVC profile durability is referenced as a source for statements on durability of aluminium and timber that have not been made in the referenced document. Durability of aluminium and timber is a key argument used by Ramboll to

[38] Recovinyl & EPPA 2021.

argue in favour of substitution but has not been justified by scientific evidence. The repeated argument has been substantiated by reference to marketing claims of sellers of aluminium and timber products only.

- The economic 'feasibility' should be based on the Total Cost of Ownership (costs of purchase, installation, maintenance and end-of-life management) rather than purchase prices only.[39] Moreover, a significant part of the necessary information is missing. Last but not least, "economic feasibility" is not defined. The authors seem to consider that even 50 % or more is acceptable, for example as mentioned in Table 7.4 (Pages 217-218) for pipes or on Table 7.8 on page 226 for window frames, but this claim is not clearly substantiated.
- The assessment of "maintenance" and "repair" does not reference state of the art definitions from EN15804 and relevant product and test standards (such as EN12608 for PVC profile systems) but refer to marketing information from sellers of products made from competing materials.
- "Commercial availability" is also questionable. Amounts of the respective materials produced in the EU and imported are generally indicated, but competition with other important uses is not well taken into account. Substituting PVC in large volume applications would undoubtedly put a lot of pressure on the supply of some alternative materials, resulting in production constraints and price hikes. The volume of PVC products would need to be mentioned along these data for the alternative materials; this is essential in order to assess the additional need that would arise from substitution. Also, some alternatives may be suitable for some sectors of an application, but not necessarily the same ones as supplied by PVC, e.g. in medical applications. This results in superficial assessments, as it does not take into account the variety of different uses and needs encompassed in an application. Assessment of this criterion appears also not having taken into account the actual market availability and scalability of listed alternatives. On p. 223 "fiber-glass windows" are listed as an alternative to PVC windows although today having a world market share of only between 3-5 % (depending on the source), without a proven case for end-of-life recycling.
- On page 244 it is stated that: "An overall reduction in human health and environmental risk is judged likely*[by using alternatives to PVC Flooring]* primarily given the presence of phthalate plasticizers in PVC flooring. " This statement is misleading. There is no evidence that phtalate plasticisers used in flooring today are a risk to health and in addition to this there is no mention of the fact that alternative non-phthalate plasticisers are available and widely used in floorcoverings.
- On page 243, the Report states that "Additives of concern in flooring include phthalate plasticisers, which can leach out of PVC and contribute to the presence of phthalates in indoor dust. Studies measuring urinary metabolites of a number of different phthalates found that children with PVC flooring in their bedrooms had significantly higher levels of the butyl benzyl phthalate (BBzP) metabolite monobenzyl phthalate (MBzP).[40] Other studies have also found correlation between PVC flooring and the presence of DiBP and DEHP in dust."[41] There are two points to address with regard to this statement:
    - DiBP and DEHP have not been used in PVC flooring in Europe for at least 10 years and so this is not a relevant factor for the proposal of alternatives in flooring or relevant to the heading of the section "*Reduction of overall risk due to transition to the alternative*". In addition, non-phthalate plasticisers exist and are already used.
    - The Carlstedt paper cited, has been countered in a letter to the editor in the same issue of the journal it appeared in (Indoor Air Volume 1, 2013). A key argument against the findings of the paper is that there is no clear evidence that the urinary phthalates found in children is linked to PVC flooring. In fact, data collected by Becker et al. (2004) showed that no correlation could be observed between the levels of the urinary DEHP metabolites in children aged between 3-14 years

[39] See for example https://www.bpf.co.uk/media/download.aspx?MediaId=1480
[40] F Carlstedt, 2012; Huan Shu, 2018.
[41] Shu, et al., 2019.

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of age and those of DEHP in house dust. DEHP can arise from a number of sources in the household, including cleaning materials.

- Recyclability aspects are covered, but in a rather qualitative way and generally not to the advantage of PVC. Use of raw materials is also covered, but other aspects of LCAs are poorly addressed.
- There are biased choices in the colours of the overall comparison tables (e.g. colouring green missing information for competing materials, instead of grey of orange). This is important, because the casual reader will most likely focus on those colours. It is unfair to PVC, for which the information is almost always available and often interpreted in a negative view.
- Substantially reducing PVC production would upset the balance between chlorine and caustic soda production and, resulting in a shortfall of caustic soda availability on the market, with many unwanted consequences.[42]

[42] https://trees.eurochlor.org/products-of-sodium-hydroxide/

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