A critique of Health Care Without Harm's latest PVC paper

In June 2021 NGO Healthcare Without Harm published a paper titled "The polyvinyl chloride debate: Why PVC remains a problematic material."[1] The target group of the paper is EU policymakers and the main message in the document is that these policymakers should develop a strategy for a PVC phase-out in Europe. The paper explicitly mentions the ongoing study by DG Environment, "The use of PVC (Poly Vinyl Chloride) in the context of a non-toxic environment" and should be read as part of a pan-European NGO campaign against PVC that also was active when the lead restriction was on the agenda in the EU Parliament.

The paper contains serious distortions

In the following we will present a critique of the HCWH PVC paper. The reason is that the paper contains so many serious distortions of the European PVC situation that the EU policymakers in our view get a totally wrong impression of the current status of PVC in Europe. If the HCWH paper should achieve any kind of authoritative status, there is a risk that more than 20 years industry efforts, innovations, and investments in polymer manufacturing, substitution of hazardous chemicals and recycling would go down the drain.

The paper does not acknowledge European progress

Our main concern related to the HCWH paper is that it might create confusion because it takes a global view on PVC issues without acknowledging the importance of the sustainable development PVC has taken up in the EU during the last decades. By only focusing sporadically on EU policy and industry, the paper gives the impression that the environmental and health issues related to PVC have not changed at all since the late 1990s when PVC was under heavy attack. By taking this approach the paper neglects the successful work being done by the European legislators when it comes to environmental regulation related to PVC issues - especially regarding additives and raw material production.

Global sustainable development starts in the EU

In principle environmental issues are global, but regulation related to sustainable development very often starts in the EU, and because of the size of the European market the rest of the world eventually has to adjust to European regulation to be able to access the European +500m wealthy consumers.[2] In order to speed up the influence on the rest of the world the European PVC industry's voluntary commitment, VinylPlus, has established a partnership with the Danish Ministry of the Environment. The objective of the partnership is to inform global stakeholders and particularly China about the newest developments regarding the substitution of hazardous additives in PVC, of which Denmark has been a forerunner.[3]

[1] https://noharm-europe.org/sites/default/files/documents-files/6807/2021-06-23-PVC-briefing-FINAL.pdf
[2] Anu Bradford: The Brussels Effect - How the European Union Rules the World, Oxford University Press, 2020
[3] https://mst.dk/service/nyheder/nyhedsarkiv/2021/maj/partnerskab-skal-sprede-hoeje-europaeiske-standarder-for-hyppigt-anvendt-plastmateriale-globalt/

From raw material production to waste management
The HCWH paper looks at the whole life cycle of PVC. Starting with the production of the raw material, it then looks at the different additives which are used to achieve the different performances PVC can provide. Then the paper evaluates the different waste management options there are for PVC waste. Finally, the document looks at alternatives to PVC.

Even though Health Care Without Harm is an NGO which deals with sustainable development within the healthcare sector, the PVC paper also deals with the use of PVC in buildings. This makes of course sense because hospitals are buildings, but also because PVC is the most used polymer in B&C as well as in medical devices.

In order to critically review the HCWH PVC paper we follow the same logic, by starting with issues raised in association with raw material production and then address the other topics mentioned in the paper.

We strictly focus on European PVC production, use, recycling and incineration. As the HCWH paper is addressed to the European policymakers, we think it is fair that we look at the issue only from a European perspective.

Raw material production
According to HCWH five substances related to the production of PVC raise concern, namely mercury, asbestos, PFAS, VCM and dioxins. All these substances have one thing in common: chlorine. Let's first look at chlorine and then at the mentioned substances of concern:

a. Chlorine production
According to HCWH, chlorine is a chemical of concern. It is correct that free chlorine in the form of gas is toxic and has to be handled in accordance with the most recent regulations so that the risks for health and environment are minimized.

Chlorine is one of the most widely produced chemicals in the world and building block for a wide range of chemical processes. It is manufactured from salt - NaCl. In 2019, about 31% of all chlorine was used for the production of PVC. The remaining 69% of the chlorine was used to disinfect drinking water and treat wastewater, in manufacturing of pharmaceuticals – up to 80% of all medicines depend on chlorine chemistry – batteries for hybrid cars, solar panels, wind turbine blades, polyurethane insulation, polycarbonate protective face shields for firefighters, and many other products. It is important to note that many chemicals, plastics and medicines use chlorine, although the end product is chlorine free. Caustic soda, which is the other product that is obtained when salt is split into sodium and chlorine, is also crucial for our society. It is for example essential for the production of alumina, pulp and paper, and plays a critical role in water treatment, drinking water purification, cleaning agents, pharmaceuticals, and food processes. Modern society would simply not function without chlorine chemistry, which HCWH does not acknowledge or chooses to ignore.

b. Mercury and asbestos
According to HCWH, chlorine production is dependent on mercury and asbestos. Yet in Europe, the

whole chlor-alkali industry today uses the membrane technology for producing the chlorine needed for manufacturing PVC. The allowed process used to manufacture the chlorine which is subsequently used to produce the PVC is included in the legally binding conclusions of the Best Available Techniques (BAT) Reference Document (BREF) for the Production of Chlor-alkali published in December 2014[4] by the European Commission, pursuant Article 13(6) of the Directive 2010/75/EU on Industrial Emissions (IED). Being not considered as a BAT, the mercury cell technology can no longer be used in the European chlor-alkali units since 11 December 2017. As a result, European chlor-alkali producers using the mercury technology converted or dismantled such facilities. Any resulting mercury-containing wastes were also addressed. Regulation (EU) 2017/852 on mercury sets rules for safe temporary storage and subsequent permanent disposal of mercury and mercury compounds.

Beyond avoiding using mercury and asbestos, using the membrane technology contributes to significant energy savings compared to other technologies. Asbestos and mercury are therefore no longer an issue in European PVC production.

c. PFAS

To HCWH, the advances in chlorine production by conversion to membrane technology do not mean PVC production is acceptable. The paper mentions the per- and polyfluoroalkylated substances (PFAS) as new pollutants that would create additional problems.

PFAS is a large family of thousands of different synthetic chemicals, broadly defined as "fluorinated substances that contain 1 or more C atoms on which all the H substituents [...] have been replaced by F atoms, in such a manner that they contain at least one aliphatic perfluorocarbon moiety such as –CnF2n–". These substances are widely used throughout society and concerns have been raised for their persistency in the environment. A European Parliament resolution of 10 July 2020 on the Chemicals Strategy for Sustainability (2020/2531(RSP)[5]) urges the Commission to set firm deadlines in the action plan on PFAS so as to ensure the speedy phasing out of all non-essential uses of PFAS, and to accelerate the development of safe and non-persistent alternatives to all uses of PFAS as part of the Chemicals Strategy for Sustainability.

Fluoropolymers are used by the manufacturers of important equipment used by the European chlor-alkali industry: membranes, diaphragms, pipework, gaskets, lining of equipment. Although not direct producing or using the PFAS, the European chlor-alkali has proactively conducted tests in collaboration with the equipment supplier to assess the potential release of some relevant PFAS in the environment resulting from their operations. Recent tests conducted in Norway has shown no detectable emissions to the wastewater (documentation available upon request).

[4] https://eippcb.jrc.ec.europa.eu/sites/default/files/2019-11/CAK_BREF_102014.pdf
[5] https://www.europarl.europa.eu/doceo/document/TA-9-2020-0201_EN.pdf

d. VCM

It is true that PVC production involves potentially toxic chemical substances like VCM. However, the document fails to mention that these substances are intermediates and are handled appropriately in a closed system. All residual quantities of VCM in waste streams from the production process are recovered and recycled back into the process. Studies conducted during the 1970s on workers in PVC polymerisation plants revealed that VCM is a carcinogen, and that significant exposure over a prolonged period can cause cancer. Yet this serious working environmental issue was solved almost half a century ago. No workers are in contact with the substance which is handled in totally closed systems. As early as 1995, the European Council of Vinyl Manufacturers' members signed voluntary charters to ensure environmental releases of VOCs, EDC, VCM, dioxins and hydrochloric acid during handling and production requirements of VCM and PVC. The charters have been regularly updated[6] so as to maintain requirements exceeding those described in the EU BAT reference documents.[7] An industry-wide compliance of the 2019 version of the charters will be externally verified by a third party certification body in February 2021.

VCM concentrations in the final PVC resins is specified by the ECVM charters to be below 1 ppm, whatever the final application and production process. As VCM is highly volatile (b.p.=-13.4°C), the VCM concentration after melting and converting the PVC resin into a final article is almost undetectable. Country-level monitoring programmes of VCM in drinking water (e.g. in France[8]) have demonstrated that PVC pipes with the current typical VCM residual concentrations supply drinking water with VCM concentrations below the most recent limit recommended by the World Health Organization (0.3 µg/l[9]). This limit has been set in order to guarantee an acceptable health risk, even in case of exposure during an entire lifetime.

e. Dioxins

Dioxins are a group of toxic substances, which have never been produced intentionally by industry. They are undesired byproducts of combustion and production processes where chlorine is present. The concerns related to the relationship between dioxins and PVC has been connected to raw material production as well as to waste incineration.[10]

Dioxin emissions from PVC production eliminated

Dioxins emissions from PVC production have been nearly eradicated during the last decades. European PVC resin manufacturers committed already in 1995 to a charter to tightly limit dioxin

[6] https://pvc.org/wp-content/uploads/2019/12/ECVM_Charter_v4.pdf

[7] https://eippcb.jrc.ec.europa.eu/reference/

[8] Direction Générale de la Santé, Instruction N°DGS/EA4/2012/366 du 18 octobre 2012, https://aida.ineris.fr/consultation_document/11647

[9] World Health Organization, Guidelines for Drinking Water Quality, 4th Ed., p.431, 2017, https://apps.who.int/iris/bitstream/handle/10665/254637/9789241549950-eng.pdf;jsessionid=A6D6B975A0ECCC619CAE7DC8681C58B2?sequence=1

[10] Alfons Buekens et al, PVC and waste incineration - modern technologies solve old problems, https://pvc.org/wp-content/uploads/2019/11/PVC_and_waste_incineration_-_modern_technologies_solve_old_problems.pdf

emissions. Manufacturing is also tightly controlled by Best Available Techniques and EU regulations. It can in this respect be regarded as symptomatic that PVC production is not even mentioned as a specific source to dioxin emission on the German Umweltbundesamt website. The main sources of dioxin emissions today are from metal, iron and steel production.[11] According to the Norwegian EPA, wood burning in homes is the main source of dioxins today.[12]

PVC waste does not contribute to dioxin formation during incineration

In the HCWH paper it is claimed that PVC in the waste results in an increased dioxin formation. This is contradictory to a conclusion in a report from 2015 published by the Danish Environmental Protection Agency on recycling of rigid PVC.[13] In the report it is stated that since 2003, when regulation on dioxin emissions from incineration plants in the EU came into force, the incineration of PVC waste no longer resulted in increased dioxin emissions.

Additives

a. DEHP plasticiser

A large part of the HCWH paper is used to describe the harmful effect of the phthalate plasticiser DEHP. Despite the fact that DEHP is still the most used plasticiser in soft PVC products globally, we do not find it reasonable to highlight the harmfulness of DEHP to an audience who have been working hard to make sure that strict regulation of the use of this substance has been implemented in Europe. Due to regulation, DEHP will be phased out in European PVC products shortly and this also goes for the use of DEHP in medical devices. Following the recent implementation of the Medical Device Regulation (EU/2017/745[14]), DEHP has been replaced in almost all PVC medical devices in Europe by non ortho-phthalate plasticisers authorised in the European Pharmacopeia.[15] DEHP is still used in some limited applications (e.g. blood bags) in which no suitable alternatives could have been found so far despite promising results obtained with substitutes.[16] When HCWH calls for the elimination of PVC in Europe because of the human exposure to DEHP, the organization either does not follow regulatory issues or chooses to ignore facts that do not fit into their anti-PVC agenda.

b. Lead stabiliser

In 2015, a voluntary replacement of lead-based stabilisers was completed by the PVC industry in the European Union. A ban on lead as a stabiliser in PVC is expected to come into force in the EU in the very near future. In contradiction to the way HCWH describes the DEHP issue, the paper is actually acknowledging this successful substitution of lead stabilisers in PVC. However, the NGO

[11] https://www.umweltbundesamt.de/themen/chemikalien/dioxine
[12] https://miljostatus.miljodirektoratet.no/tema/miljogifter/prioriterte-miljogifter/dioksiner-og-furaner/
[13] https://www2.mst.dk/Udgiv/publikationer/2015/05/978-87-93352-30-8.pdf
[14] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L:2017:117:FULL&from=EN
[15] https://www.edqm.eu/en/news/ph-eur-revised-its-general-chapters-plasticised-pvc-materials
[16] https://www.edqm.eu/sites/default/files/medias/fichiers/Transfusion/Events/plasticizer_deht_by_linda_larsson.pdf

criticises the EU policymakers to be too slow to regulate lead, and industry to be too slow to phase it out.

Recycling of lead-containing PVC is currently being discussed in the EU. According to ECHA recycling in applications such as three-layer sewer pipes or as middle-layer in window frames is preferable to incineration or landfilling.[17] Not surprisingly is HCWH against recycling of lead-containing PVC; however it does not propose any sustainable solution on handling such wastes.

HCWH also fails to mention that lead is still crucial to a wide range of products that are essential to modern society. For instance, radiation therapy for cancer treatment and renewable energy production like solar panels all use lead. Recycling of lead is also taking place. Recycled lead is used in car batteries and in listed buildings to mention a few applications.

Risks and impacts with PVC Pipes

HCWH claims that PVC pipes in municipal water and sewer infrastructure cause benzene emissions when exposed to high temperatures in the context of wildfires.

As recalled in the HCWH paper, forest fires devastated the California municipalities of Santa Rosa and Paradise in 2017 and 2018. A study of Santa Rosa's municipal water system[18] has showed that benzene had been detected in their drinking water. Some media reports incorrectly suggested PVC water mains were the source of the benzene. This is not possible since both communities confirmed that no PVC water transmission or distribution mains were affected by the fires and remained in service throughout the events. Both utilities have kept PVC pipe in their specifications and continue to use it. According to Kevin Phillips, District Manager of Paradise Irrigation District, Paradise's PVC pipelines "performed not only during the fire but after they were depressurized and then refilled." PVC water mains are used by the U.S. National Forest Service for its underground infrastructure in forested regions across the country – areas which are regularly affected by wildfires.

The primary source of benzene in forest fires is from the combustion of wood.[19] Burning homes and other structures are secondary sources. Benzene cannot be produced from PVC combustion in an open-air fire. Some reports[20] suggest trace amounts of benzene can be released in a process known as pyrolysis, when it is heated above 350°C in a highly controlled environment in which air is completely absent. However, pyrolysis of buried PVC water mains does not occur during wildfires. For these additional reasons, PVC water pipes could not have released the benzene found in the drinking water in these communities.

The most likely source of benzene in municipal water systems after a wildfire is not from burning or melting water mains but from outside contaminants entering the system via damaged service lines.

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[17] https://echa.europa.eu/documents/10162/86b00b9e-2852-d8d4-5fd7-be1e747ad7fa

[18] https://srcity.org/DocumentCenter/View/19837/Post-Fire-Water-Quality-Investigation-Analysis-of-Cause-of-Water-Contamination

[19] https://emergency.cdc.gov/agent/benzene/basics/facts.asp

[20] https://www.sciencedirect.com/science/article/abs/pii/S0956053X15302233?via%3Dihub

When a building burns, the service lines that connect to the water mains break, burn and melt, creating gaps where contaminants can enter into the water system. As water in the system is used to fight the fire, suction draws in contaminants. This process is called backflow[21] and can occur regardless of pipe material. It has also been suggested that benzene can permeate through PVC pipes after accumulating in the soil following wildfires. However, published studies[22] confirm that gasketed PVC pipe is highly resistant to permeation from a wide range of chemicals, including benzene.

Several EN 15804-, ISO 14040- and ISO 14044-compliant comparative LCA studies[23] undertaken by the Flemish Institute for Technological Research (VITO) and critically reviewed by the Austrian sustainability consultancy Denkstatt, have confirmed that, for most of the environmental impact criteria, PVC pipe systems have a lower environmental impact when compared to the alternative pipe materials assessed.

Several independent lifecycle cost analyses[24] have also demonstrated the cost benefits of using PVC pipes instead of other materials for water and sewer pipes. Selecting PVC instead of other materials allows significant cost savings at all stages of the infrastructure life cycle. These savings are most significant for the construction costs incurred during the installation stage.

Incineration

We agree that incineration of PVC and other chlorine containing wastes is not a sustainable solution. The reason is that the waste is partly transformed into incinerator bottom ash or fly ash which contains heavy metals and therefore must be disposed of as hazardous waste.

It has been reported by the Danish Environmental Protection Agency that PVC waste is responsible for around 5% of these residues. Today the fly ash from the Nordic countries is mainly stored safely on the Norwegian island Langøya or in abandoned German salt mines. In the rest of Europe the fly ash is also deposited safely.

The good news is that this environmental challenge can now be solved. We are talking about a groundbreaking technological breakthrough and it is remarkable that it has not come into the attention of Health Care Without Harm and mentioned in their PVC paper. We are referring to the so-called HaloSep[25] process which has been developed in Denmark during the last decades. During the last five years the project has been financially supported by the EU Life Programme with €2.2 million. In the beginning the project was also partly financed by VinylPlus. At the moment a full scale demonstration plant has been built in an existing incineration plant near Copenhagen.

HaloSep offers a solution to managing all the issues of fly ash. The process recovers salt and metals and reduces the landfill volume. HaloSep is an on-plant solution that can be built up locally at existing Waste

[21] https://www.awwa.org/portals/0/files/publications/documents/m14lookinside.pdf
[22] https://www.waterrf.org/research/projects/impact-hydrocarbons-pepvc-pipes-and-pipe-gaskets
[23] https://www.teppfa.eu/sustainability/environmental-footprint/lca/
[24] e.g. https://pvc4pipes.com/wp-content/uploads/2019/05/PVC-U_Pipe_Competitiveness_A_Total_Cost_of_Ownership_Approach_ALTHESYS.pdf
[25] https://lifehalosep.eu/

to Energy plants. It can also be placed at a site where fly ash from several smaller plants is consolidated. Thereby, HaloSep will eliminate both cost and emissions related to long-range transportation.

It must be stressed that according to the EU waste hierarchy incineration of waste is not a preferred waste management option. Reducing, reusing and recycling are better options than incineration. Only when PVC waste cannot be reused or mechanically recycled then the incineration with energy recovery is preferred, ideally with the aforementioned HaloSep solution in combination with carbon capture technology in place.

Reuse of PVC waste

Talking about the waste hierarchy, *reuse* of PVC waste can actually take place. Progress is being made in Denmark in order to reuse PVC building waste. A project financed by VinylPlus has been running for the last four years.[26] The objective is to reuse PVC installation waste from the building industry to build gardens in urban areas. The idea is to prolong the life of the waste by transforming the waste into useful plant containers. After service life in urban farming the pipes can be recycled. In addition, the project wishes to encourage local communities to adopt a very cheap solution to build a garden and grow healthy food. The project involves architects, green enthusiasts, hospitals, local authorities and the PVC industry. In contradiction to what HCWH claims, PVC is not only a polymer which is very well qualified for recycling (see below) – direct reuse in urban farming is also an option for some types of PVC waste.

Mechanical recycling

"PVC is the … least recyclable of all plastics," HCWH wrongfully claims in the report.

In 2020, more than 730,000 tonnes of PVC waste were recycled in the EU through VinylPlus®. Since 2000 more than 6.5m tonnes have been recycled, which saved the emission of about 13m tonnes of CO2.[27] In a recent report from the Danish Technological University it is even said that PVC is the most recycled plastic in the Danish building sector.[28]

PVC can be recycled repeatedly (more than eight times in laboratory tests) depending on the application, because the recycling process does not measurably decrease the chain length of PVC molecules. This has been proven by tests performed on PVC pipes.[29]

HCWH also does not seem to be aware that successful projects in Australia, New Zealand, the UK and other countries show a great potential to collect PVC medical devices and recycle them into useful products. Hospitals save money by diverting waste from expensive treatment processes for clinical waste and at the same time contribute to the circular economy, reduce carbon emissions and help save energy. The collection and recycling are done without risk to hospital staff, patients or recyclers as the

[26] http://pvcreuse.farm/
[27] https://vinylplus.eu/progress/annual-progress
[28] https://www.danskindustri.dk/siteassets/medlemsforeninger/dansk-byggeindustri/publikationer/plastprojekt-2020-2021/innobyg_rapport_med-bilag_11-12-20.pdf
[29] Leadbitter J, Bradley J. Closed loop recycling opportunities for PVC. Current Trends in PVC Technology Conference. Institute of Polymer Technology and Materials Engineering, Loughborough University; 3–4 November 1997.

collection is limited to PVC medical devices which have only been used on pre-screened patients and have not been in contact with bodily fluids or medicines. This practice can be likened to collection schemes for deposit bottles.

A prerequisite for successful plastics recycling is mono-streams. As most PVC-based medical devices are made from only one polymer, they are ideal for recycling. Non-PVC medical devices are often made from a combination of different polymers with multiple additives, which makes recycling impossible with current technologies.[30]

When it comes to buildings, we must not forget that PVC have unique properties which make it a material that can contribute positively to solving some of the main challenges our society faces. And this positive contribution refers not only to the products that are being manufactured by PVC, but also to the durability and recyclability of these products. Take for example the PVC pipe, which is being criticized in the HCWH paper. PVC pipes are essential in our infrastructure, have a service of life of +100 years and can be recycled many times without adding new raw material. Such a performance will be difficult to match by other plastics or any other material.

Alternatives to PVC

"PVC can be replaced with safer materials in virtually all cases", the HCWH paper claims.

This is simply not true. In a Danish report on soft PVC published a few months ago – "Circular Visions for Soft PVC" – conducted by Ramboll, which is also conducting the study "PVC in the context of a non-toxic environment" for DG Environment, it is concluded that it will be very difficult to produce similar goods without the use of soft PVC. By "similar goods" the study refers to a wide range of soft PVC products like vinyl flooring, roofing membranes, tarpaulins, advertising banners or cultural event streamers, flood protection equipment, bouncy castles, sports equipment and medical devices. The Ramboll report says that:

"The hallmarks of soft PVC render it suitable in these particular products for a number of reasons including wear resistance, weather resistance, service life, safety and other very specific characteristics."

And in the context of circular economy the report says:

"Soft PVC has a long service life. In the context of the circular economy and optimal sustainability, where soft PVC products are made recyclable, trade users could achieve significant resource savings since soft PVC production would have recourse to recyclate as an alternative to using virgin materials."[31]

The HCWH paper also has the premise that replacement of PVC by alternative materials is preferable. Documentation, however, is lacking, and it is highly doubtful if any non-PVC products are better for health and environment. According to a report by the Danish EPA, "it cannot be concluded from available

[30] https://pvc.dk/2019/11/27/hvordan-kan-plasten-i-sundhedsvaesenet-genanvendes/
[31] https://pvc.dk/wp-content/uploads/2021/06/SAMLENOTAT_cirkulaere-visioner-for-blod-PVC_endeligt-en.pdf

LCAs that another type of plastic is generally better than PVC … The alternatives will typically be slightly more expensive than PVC and/or have technical properties minor to PVC."[32]

Conclusions

In this paper we do not argue that PVC is a fully sustainable product nor that it is becoming a sustainable product just because we in EU have substituted the problematic additives, increased our recycling figures every year, or invested in developing solutions to the issues related to incineration. The VinylPlus Voluntary Commitment is seeking sustainability in a holistic step-by-step approach, and it is a long journey. But we have come a long way on that journey.

While HCWH ignores these steps toward sustainability there are fortunately others who acknowledge the progress being made by the PVC industry. For example, the UNIDO Representative to the European Union, Christophe Yvetot, have said that "in the race for sustainability the laggards will lose. We see the VinylPlus initiative as the forerunner and role model for a global standard of the industry." Many other stakeholders from international organisations and bodies have also praised VinylPlus.[33]

At the moment hospitals all over the world discuss how to improve their environmental performance. They are especially looking for recycling options for single use medical devices. As PVC is the most used polymer in medical devices, we urge the health sector to start with this fraction. Unfortunately, Health Care Without Harm chooses another direction in wanting to phase out PVC altogether. By going through their PVC report in this document, we hope to have shown that most of HCWH's arguments for a PVC phase-out are either outdated or simply wrong. If hospitals and the rest of the health sector listen to Health Care Without Harm on PVC related matters, we are convinced that they will do more harm than good.

In short, the assertion of HCWH that "PVC is the most environmentally damaging type of plastic and safer alternatives are already available for virtually all uses of PVC" is clearly misleading and not substantiated in any way.

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[32] https://www2.mst.dk/Udgiv/publikationer/2018/11/978-87-7038-000-3.pdf
[33] https://vinylplus.eu/stakeholders?page=stakeholders