Impact of lead restrictions on the recycling of PVC

16 July 2013

Tauw

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Responsibility

Title	Impact of lead restrictions on the recycling of PVC
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Project number	4827864
Number of pages	54 (excluding appendices)
Date	16 July 2013
Signature	Is missing due to digital processing. This report is demonstrably released.

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Summary

Introduction

The use of lead-based stabilizers in the production of PVC articles is decreasing fast. This is a result of the voluntary commitment of the PVC industry to replace lead based stabilizers before the end of 2015. On the other hand the use of lead and its compounds is also restricted by EU legislation through the RoHS Directive, the Packaging Directive and the ELV Directive. Lead and many lead-containing substances have recently been included in the REACH Candidate List, which might lead to inclusion in Annex XIV of REACH. A restriction proposal (REACH Annex XV) for lead in consumer articles which children can put in the mouth has recently been submitted for public consultation. This can result in more restrictions on the presence of lead compounds in PVC.

Legislation restricting the presence of lead in articles might have a negative impact on PVC recycling: lead-containing recycled PVC could no longer be used to produce new PVC articles. This could undermine the PVC industry’s commitment to significantly increase the volume of recycled post-consumer PVC waste and thus enhance the sustainability of the PVC chain. It would also undermine the goals of the European Commission with regard to resource efficiency. Indeed a restriction on lead in articles might result in using less recycled post-consumer PVC waste. As a result more PVC would have to be sent to landfill and incineration.

What would restriction look like?

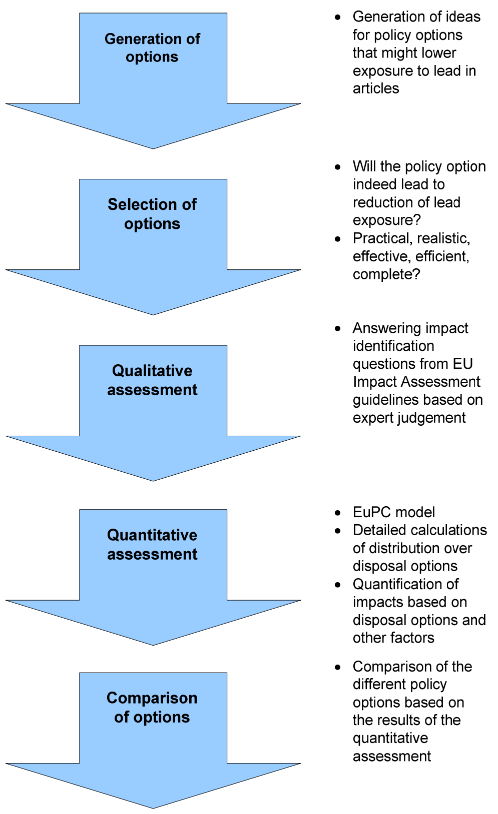
An Impact Assessment was performed on the basis of several policy options, i.e. options to restrict the content of lead. Such measures are usually legally binding but they can also be voluntary commitments. This Impact Assessment considered the following policy options.

Option 1: no change in current EU regulations	This is the "Business As Usual (BAU)" option or the reference case whereby there is no additional restriction to the use/content of lead beyond the current legislative framework (REACH Annex XVII, RoHS, Toys safety Directive, Packaging Directive and ELV Directive). In addition the voluntary commitment of the PVC industry to replace lead stabilizers before the end of 2015 will be completed.
Option 2: restriction of lead in articles to max 0.1 %	It would be prohibited to place on the market articles containing lead compounds, when the content of the substance in the product (considered as an homogenous part) is greater than or equal to 0.1 % of lead by weight. This would restrain the addition of recycled PVC to virgin PVC resin to a maximum of around 10 % in most cases. Such low rates usually do not justify the investments and additional running costs needed to co-process recycled PVC.
Option 3: restriction to max 0.1 % with exemption of building products	This is similar to option 2, except that an exemption is made for building products. Drinking water pipes are not considered as building products for the sake of this Impact Assessment. As recycled PVC is to a large extent applied in building products Option 3 still enables significant recycling. Emission of lead from building products is assumed to be very low: articles like window profiles, pipes and flooring materials, do usually have an external layer of virgin material.
Option 4: restriction to max 0.1 % with exemption to max 1 % for building products	This is comparable to option 3, except that a maximum content of 1 % (as lead) in building products would be imposed.
Option 5: restriction to max 0.1 % with either exemption (as in option 3) or 1 % limit (as in option 4) for building products for a limited period of time.	*Option 5A.* This option is comparable to option three: a restriction of lead in articles with an exemption for lead in building products; however the exemption would be reviewed after a specified limited time.
	Option 5B. This option is comparable to option four: a restriction of lead in articles with an exemption for lead in building products with a maximum lead content of 1 %; however the exemption would be reviewed after a specified limited time.
Option 6: restriction of lead to max 0.1 % in directly accessible parts of articles	In this option, the restriction would apply to the lead content in the outer layer of an article made of recycled material. The reasoning behind this option is that the exposure is negligible/non-existing if lead is only present inside an article. A problem is though how to define "directly accessible": which thickness of surface would this include?

Option 7: restriction of lead to max 0.1 %, except when the leaching is proven to be below a certain limit value	In this option a product could be placed on the market provided that the producer can prove that leaching of lead from the product is so low that the human health and the environment is not at risk.
Option 8: non regulatory option - Bilateral agreement with PVC recyclers and PVC converters	The PVC industry has already committed to the phasing out of intentionally added lead stabilizers. To further reduce the impacts of lead included in PVC a remaining option would be to remove lead from PVC. This would include separation of “lead-rich” PVC or removal of lead from the PVC matrix. These options would demand significant energy input and are not considered to be economically viable.
Option 9: restriction to max x% lead in articles intended for consumer use, in any individual part of the article, which could pose a risk for human exposure to lead via inhalation or ingestion	An advantage of this option would be that the groups deemed to be most vulnerable, e.g. children, would be better protected from lead exposure as “consumers” includes this group. However, “consumer use” is not well defined.

Approach of the Impact Assessment

The Impact Assessment was performed in five steps, as depicted below.



Generation of options

On the basis of earlier regulations concerning substances in articles and general knowledge of EU legislation several options were identified that could possibly aim at reducing lead exposure from PVC.

Selection of options

Several of the options listed above were not evaluated further because it was considered that they would not contribute to the final goal of reducing the impacts of lead. Other options were found not pragmatic, for instance due to problems foreseen upon interpretation. As a result, only the following three options were selected for quantitative Impact Assessment:

Option	Short description
Option 1	Business As Usual (BAU) No change in EU policy
Option 2	Restriction to max 0.1 %
Option 5B	Same but exemption for construction products with a maximum lead content of 1 %, until review date

For these options social, economic and environmental impacts over the entire lifecycle were assessed by following -as far as relevant and practical- the Impact Assessment Guidelines of the European Commission. The assessment was done for profiles, pipes and fittings, flooring, roofing and electrical cables. These are applications which are known to have contained lead in the past and which are recycled into new articles in significant amounts.

Qualitative assessment

The EU Impact Assessment guideline was followed to determine the most important impacts per scenario. Per possible type of impact the likelihood of such impact to happen and the magnitude of impact were assessed on a qualitative basis. With this approach the most important impacts can be identified. These were:

Important impacts to be considered
• Opening or closing of businesses • Financial effect • People becoming unemployed/getting a job • Health consequence (number of people with a elevated blood lead level) • Extra CO_2 emitted • Energy demand • Use of crude oil/natural gas and NaCl • Amounts of waste recycled, incinerated, landfilled and exported

Quantitative assessment

Impacts of options are related to the waste stage of PVC. They are determined by the way in which PVC waste is managed. PVC waste can easily be recycled; it may however also be disposed of by incineration or landfilling. It is therefore important to know how much PVC waste goes in each direction. This is determined by the ratio of lead concentration in waste PVC to the maximum concentration of lead allowed in articles. If this ratio is very high, it will only be possible to incorporate a very limited amount of recycled PVC in order to avoid that the lead concentration in the new articles might exceed the restriction limit of a proposed regulatory option.

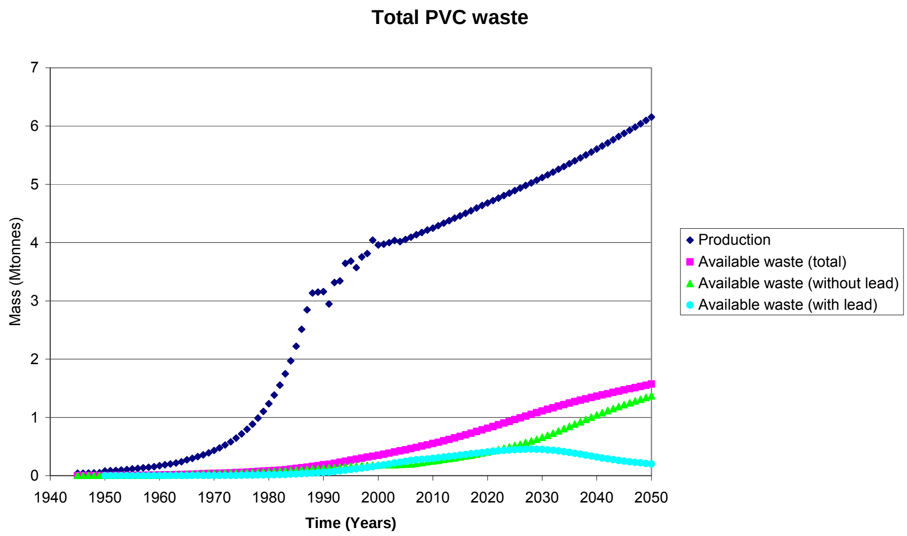
As low rates of incorporation of recycled PVC usually do not justify the investments and additional running costs needed to co-process recycled PVC this might result in a higher amount of PVC going to landfill/incineration instead of recycling. It must be noted that lead concentrations in waste PVC (and therefore in recycled PVC) will decrease slowly over time. Over time and varying per option, there will be a period when PVC cannot be recycled extensively due to a high level of lead, followed by a period when recycling becomes more attractive.

Calculations were based on the Dynamic Waste Analysis tool of EuPC (European Plastics Converters). This model predicts the amount of PVC waste arising based on past production and average lifetime, and expected production data per application. The tool was adapted to allow for modelling the amount of lead-containing waste.

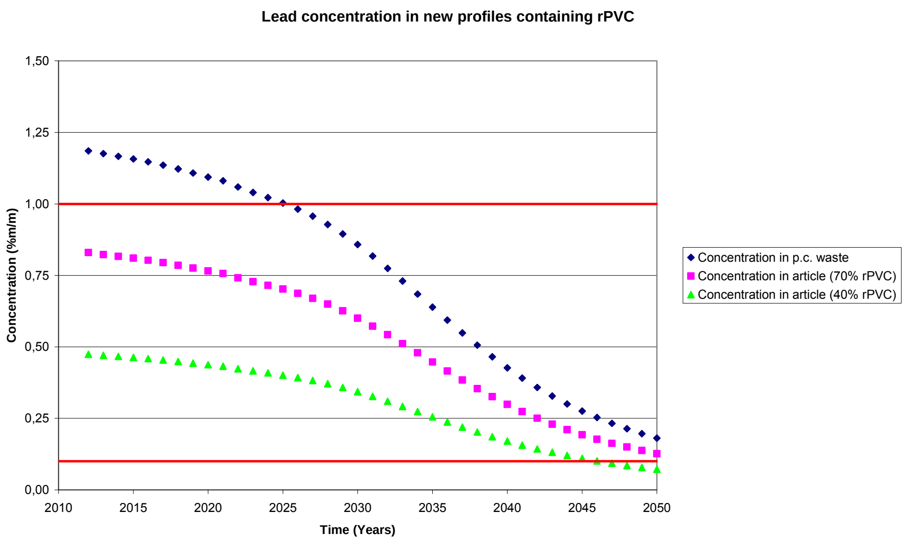
An average lead concentration was calculated for the total waste from each of the main application selected for this study (profiles, pipes and fittings, flooring, roofing and cables). This calculation was based on the total waste arising from each of the considered application and on the fraction of this waste containing lead. Subsequently the lead concentration in new articles made from recyclate was calculated for the different applications. Based on these findings and assumptions on waste management in Europe the distribution over the four disposal ways (recycling, incineration, landfilling and export) was calculated for the options 1, 2 and 5B.

In addition to the given options extra effects of new EU policies as described in the Seventh Environmental Action Program (7EAP) were assessed. 7EAP builds further on the Resource Efficiency Roadmap of the European Commission. 7EAP requires that waste is managed as a resource, energy recovery (by incineration) is limited to non-recyclable materials and landfilling of recyclable materials is effectively eradicated. As an alternative to each of the regulatory options considered, a sub-option was considered whereby no PVC is landfilled by 2020 and only 10% of PVC waste is sent to incineration.

The following two figures illustrate the results of the calculations. “Total PVC waste” refers to the sum of the five applications considered (profiles, pipes and fittings, flooring, roofing and electric cables).



PVC waste arisings EU-15, five selected applications



Lead concentration in new profiles containing rPVC and lead concentration in PVC profile waste

The first graph shows that the total arisings of PVC will increase over time, though remaining during several decades behind the curve of PVC production.

The second graph shows the evolution of the lead concentration in PVC profile waste as a function of time.

As can be concluded from these graphs, the arising of lead-containing PVC waste will decrease slowly over a long period of time. As a result, the lead content in new articles made from recycled PVC will also decrease only slowly. In case the lead content in PVC would become restricted to 0.1 %, recycling would not become possible until approximately 2050. It is assumed that if recycling activities would stop they would not re-start again due to the significant investments needed and the loss of know-how.

Results of Impact Assessment

The detailed impacts of the selected options are as follows. It is anticipated that PVC waste exported out of the EU will be destined for recycling.

Management of PVC waste

Policy option	Recycling (tonne)	Incineration (tonne)	Landfilling (tonne)	Export (tonne)
BAU	14 533 267	18 001 887	1 719 665	7 340 285
Option 2	2 489 758	19 589 685	1 719 665	17 795 996
Option 5B	14 533 267	18 001 887	1 719 665	7 340 285
Option 2 EAP7	5 367 102	2 792 456	532 878	32 902 668
BAU/option 5B EAP7	30 057 324	2 792 456	532 878	8 212 445

Social and economic effects

Policy option	Number of recycling companies (-)	Difference from BAU (-)	Jobs in recycling + jobs in converting as a result of recycling (-)	Difference from BAU (-)	Financial effect from 2015 to 2050 [MEUR]	Difference from BAU [MEUR]
BAU	154	0	968	0	9 287	0
Option 2	26	-128	166	--802	1 591	-7 696
Option 5B	154	0	968	0	9 287	0
Option 2 EAP7	57	-97	358	-610	3 430	-5 857
BAU/option 5B EAP7	319	+165	2001	+1033	19 207	+9 920

Energy use and CO_2 emissions

Policy option	Amount of greenhouse gasses prevented (tonnes CO_2-eq)	Difference from BAU (tonnes CO_2-eq)	Primary energy use prevention (MJ PE)	Difference from BAU (MJ PE)
BAU	21 282 311	0	369 467 100 209	0
Option 2	14 646 419	-6 635 892	332 266 085 259	-37 201 014 950
Option 5B	21 282 311	0	369 467 100 209	0
Option 2 EAP7	63 636 562	42 354 251	420 208 846 549	50 741 746 340
BAU/option 5B EAP7	68 245 772	46 963 461	480 017 366 682	110 550 266 472

Use of materials

Policy option	Raw material consumption of Oil/Gas/condensate/coal/lignite (tonne)	Raw material consumption of salt (tonne)	Difference from BAU (tonne Oil/Gas/ condensate/coal/lignite)	Difference from BAU (tonne salt)
BAU	22 999 851	10 748 535	0	0
Option 2	24 808 272	11 681 978	1 808 420	933 443
Option 5B	22 999 851	10 748 535	0	0
Option 2 EAP7	3 891 087	1 789 659	-19 108 765	-8 958 876
BAU/option 5B EAP7	3 891 087	1 789 659	-19 108 765	-8 958 876

Option 2 comes out as particularly unfavourable. Both economy and environment will be negatively impacted. This is due to the fact that recycling is made more difficult. Option 5B on the other hand allows maintaining recycling into construction products and hence its impact is equivalent to BAU as far as construction applications are concerned. Other applications would still be impacted, but have a smaller impact as they are recycled to a lesser extend.

All routes of exposure to lead in the various stages of the lifecycle of PVC were analysed. There are two main reasons why exposure to lead must be considered to be negligible:

- It is unlikely that humans “mouth” PVC articles for a long period
- Recycled PVC in articles considered here is mostly used in non-accessible applications. For instance, it is used in the inner layer of window profiles and of pipes.

No difference related to the exposure of lead exists between the options considered.

Conclusions

In order to limit the exposure of lead to humans and the environment, restrictions on the use/content of lead in articles might be set. This study looked into five prominent types of PVC articles: profiles, pipes and fittings, flooring, roofing and electric cables. A restriction might be introduced in the form of an EU regulation. This study identified several policy options and compared three of them in depth.

Option 1	Business as usual. No change in European policy
Option 2	Restriction to max 0.1 %
Option 5B	Same but with exemption for construction products with a maximum lead content of 1 % until review date

Of these options, option 2 would result in significant negative impacts on economy (loss of jobs, fewer companies) and environment (less recycling, more CO_2-emissions, more use of resources). Between these options there is no difference with regard to impacts to human health.

Option 5B is considered to be the best overall option to restrict the presence of legacy lead based stabilizers while at the same time continuing to develop recycling, creating jobs and saving on CO_2-emissions and resources.

1 Introduction

1.1 Introduction

Following a 2011 proposal by the Norwegian Climate and Pollution Agency to ban lead in consumer products, VinylPlus has commissioned Tauw BV to perform an impact assessment on potential restrictions of lead in PVC. Since 20 August 2012 all lead substances used in lead stabilizers are listed on ECHA's Registry of Intention to be identified as SVHC [ECHA]. On December 19th 2012 these substances were included in the Candidate List for eventual inclusion in Annex XIV to REACH. This paves the way towards the possible inclusion in Annex XIV of REACH, the annex of substances subject to authorization. Inclusion in this Annex can lead to a ban on the use of lead as a stabilizer for PVC. This brings the PVC industry into a comparable position as in 2009 when cadmium was included in REACH Annex XVII resulting in restrictions for cadmium as a stabilizer under REACH. At that time an impact assessment study was conducted which resulted in a report comparable to the present report [VITO].

In the current impact assessment special consideration has been given to the impact that possible European legislation for restrictions on the use of lead in PVC might have on recycling of PVC. This report describes the results of the impact assessment study which was executed in the second to fourth quarter of 2012 and first half of 2013.

1.2 What is the problem in short?

Several categories of articles contain lead. Lead can be detrimental to human health [VRAR, WHO]. Therefore voices are raised that restrictive regulations for lead in all articles placed on the market should be put in place in the European Union. Some European countries already have more stringent lead restrictions in place. Others are considering such restrictions [COWI]. On a European level procedures have been started to examine all lead based substances in PVC stabilizers, with the aim to decide if these substances should be subject to authorization or restriction.

The PVC industry has participated in the voluntary risk assessment for lead, which showed that the risks of lead as a stabilizing agent in PVC are negligible [VRAR]. Even though the risk is negligible, the PVC industry is committed to phase out intentionally added lead-based stabilizers by the year 2015 [VinylPlus]. Legislative restriction of lead in articles might result in a decrease in PVC recycling as lead containing PVC waste would be restricted from being used in new products.

The PVC industry is committed to a significant increase in the volume of recycled post-consumer PVC waste in order to enhance the sustainability of PVC. A restriction on lead in articles would result in lower recycling rates of post-consumer PVC waste, more landfilling and incineration of PVC waste and therefore an increase of the environmental impact as well as adverse economic and social impacts.

1.3 Objectives of the study

In this study we have identified different options for potential regulation of lead in PVC products. The study has assessed in a qualitative way the different options and some of the options were investigated further on a quantitative scale. For these options the social, economic and environmental impact over the entire lifecycle were assessed by following as far as relevant and practical the Impact Assessment Guidelines of the European Commission.

1.4 Scope

This impact assessment has been performed with regard to possible regulation of the European Union. This regulation is directly applicable in the member states. Therefore the most logical scope for this impact assessment would be the EU 27. However, insufficient data for the EU 27 is available. For the EU 15 more data is available, therefore the scope has been limited to the EU 15. The time span taken into account starts in the year 2015 and extends until 2050.

This impact assessment is limited to the impact of a lead restriction in articles made of PVC. The most likely regulation would be a more general restriction of the use of lead in all articles. An assessment of a restriction on lead in other articles than those made of PVC is beyond the scope of this study.

The impact assessment is restricted to the following key PVC applications:

1. Profiles
2. Pipes and fittings
3. Flooring
4. Roofing
5. Cables

The first four items in the above list are products that are frequently made with recycled material of post consumer PVC waste [PE et al.]. The last group of articles, cables, contains no post consumer waste at the moment. The waste PVC from cables is recycled in other products however. All these applications contain, or have contained, lead in the past; therefore recycling of these articles might lead to a certain lead concentration in a new article.

1.5 Have the minimum standards for impact assessment been met?

The impact assessment was executed as much as possible according to the Impact Assessment guidelines given in SEC(2009)92. As the IA wasn't commissioned by the European authorities the guidelines cannot be followed directly. The guidelines were followed as far as relevant and practical. Consultation strategy was based on information needs instead of providing the option for all stakeholders to express their opinion.

In lead and all lead compounds the toxic chemical segment, is the lead ion which can be liberated. As different lead stabilizers are used such as lead stearate or Tetra-basic lead sulphate, the amount of lead will vary if the limit value is given for the different stabilizer compounds. Therefore in this report the thresholds (limit values) are expressed as elemental lead. This avoids having to set-up different limits for different stabilizers whose lead content may vary widely.

1.6 Reader's guidance

This report contains two parts. The main part (chapter 1 to 7) describes the Impact Assessment by following the methodology of the guideline for Impact Assessment as mentioned above. This main part describes the results of detailed studies and calculations. Detailed information can be found in the several annexes to this report.

The main report contains the following chapters.

Chapter	Contents
2	This chapter informs about the features of lead and impacts from it. It explains the problem of restrictions on the use of lead with regard to recycling.
3	In this chapter the objectives of putting in place regulation that aims at restrictions on the use of lead are outlined.
4	Here we describe in detail possible policy options to restrict the use of lead. Those options are selected that are considered to be reasonable and feasible. They will be subjected to an Impact Analysis.
5	In this chapter a full assessment of the selected options is performed. In the first place a qualitative assessment is done, identifying the relevant issues that need a further quantitative analysis. The full quantitative analysis is presented.
6	The results of the Impact Analysis are summarized in this chapter and conclusions are drawn.
7	Conform to the guidelines for Impact Assessment the issues of monitoring and evaluation are elaborated on.

1.7 Literature for chapter one

[ECHA] http://echa.europa.eu/web/guest/candidate-list-table?search_criteria=lead. Accessed June 19th 2013

[VITO] Study on the cadmium content of recycled PVC waste, Study commissioned by Vinyl2010, 2009/TEM/R/189, December 2009

[VRAR] Voluntary Risk Assessment Report on lead and some inorganic Lead Compounds, Lead Development Association International, March 2008

[WHO] http://www.who.int/water_sanitation_health/diseases/lead/en/

[COWI] COWI Consulting Engineers and Planners on behalf of Nordic Council of Ministers, Lead Review, January 2003

[VinylPlus] Vinyl plus voluntary commitment. http://www.vinylplus.eu/en_GB/resources/publications/voluntary-commitment

[PE et al.] PE Europe and consortium: Life Cycle Assessment of PVC and of principal competing materials, July 2004

2 Problem definition

2.1 Introduction

This chapter explains the concerns associated with lead in PVC articles. They are described more in detail in paragraph 2.2. A simple ban on lead in articles would eliminate these concerns while at the same time directly lead to other problems. The latter problems are discussed in paragraph 2.3. The root causes and drivers are given in paragraph 2.4. The stakeholders affected are given in paragraph 2.5. Paragraph 2.6 describes the situation with no regulatory action from the European Union. The EU right to act is described in paragraph 2.7.

2.2 Problem of human and environmental exposure to lead

Lead can have a detrimental effect on human health and the environment [VRAR]. At high levels in the human body lead can damage various organs. Acute lead poisoning and the resulting organ damage is very rare nowadays, due to proper hygienic measures and phase out of lead in the relevant places in society. However, even at low doses lead remains of concern for the developing brains of young children as well as to unborn children through pregnant women [WHO]. The general public is exposed to low doses of lead only from many different sources of which dietary intake is the major source of exposure [EFSA]. Lead can accumulate in the environment and cause damage to the ecosystem [COWI]. Over the years several lead restricting legislative actions have been implemented, starting with the lead emissions that had the highest impact on health. The use of leaded gasoline for cars, the major contributor to high blood lead in the population, ended in Europe in 2002. The use of lead in car components, except in specific parts, was ended in 2003 (ELV regulation) and lead in electronics was restricted in 2006 (RoHS regulation). Additionally some member states of the European Union have additional lead restrictions in place [COWI]. Lead is still used in many applications, among which in some specific PVC articles.

As the presence of lead in any article can potentially contribute to increase the lead burden in the human population and the environment voices are raised that the EU should impose regulations to limit the use of lead in articles. This would have the benefit of levelling the playing field in Europe as some member states have stricter regulations than others.

2.3 Problem of lead ban for PVC recycling

A ban on lead in articles as mentioned in paragraph 2.2 would hardly hamper the production of PVC products made of virgin material as the use of lead stabilizers is almost phased out and will be definitely discontinued before the end of 2015 anyhow. However a total ban of lead in all articles would affect the production of PVC products made of recycled PVC as lead is present in PVC waste. This would severely hamper the recycling of PVC waste and therefore the benefits of recycling which include recuperation of material resources and energy.

2.4 Root causes and drivers

In order to find the root cause of the problems an analysis has been made to find the drivers for the problems given in 2.2 and 2.3. The problems and drivers are given in table 2.1.

Table 2.1 Problems and drivers

Problem	Drivers
Health degradation because of exposure to lead	Lead is used for different reasons in articles. During manufacturing, use and at end of life of lead containing products people may be exposed to the lead contained in these products. In most cases lead is the cheapest material applicable and lead is often technically superior to other substances.
Environmental degradation because lead will accumulate in the environment	Lead is used for different reasons in articles. During manufacturing or use of lead containing products and more specifically at the end of life of these products lead may be emitted to the environment. In most cases lead is the cheapest material applicable and lead is often technically superior.
Loss of material resources	In many cases disposal is cheaper than recycling. Recycling is often impeded by (waste) legislation.

2.5 Who is affected, in what ways, and to what extent?

Different groups of people would be affected by a potential ban on lead in articles. In this paragraph the different groups are identified and the effects are described qualitatively. In the rest of this report an extended description of effects is given.

2.5.1 Impact on health of specific groups

Reducing the amount of lead in articles reduces the exposure of European inhabitants to lead. This will most likely improve the general health of all the European citizens. The main indicator for exposure of humans to lead is the blood lead level. Reducing the amount of lead in articles in general will probably result in a lower blood lead level. An elevated blood lead level is associated with different health problems. As most European citizens show no elevated blood lead levels the effect of reducing lead in articles on individuals will be small. However the number of people with elevated blood lead levels will most likely decline.

There are specific groups who will benefit more from a restriction of lead in articles than other groups as they are more vulnerable to lead exposure. These groups are unborn children, through pregnant women, and children. The higher vulnerability of these groups is expressed by the lower No observable adverse effect level (NOAEL). These NOAL's proposed in [VRAR] are given in table 2.2. It should be noted however that only a small part of the different groups has an elevated blood level. The average blood lead level in Europe is indicated to be approximately 2 - 3 µg/dL.

Table 2.2 NOAEL's for different groups

Health effects endpoint	NOAEL	Exposed population
Nervous system effects (adult)	40 µg/dL	Adults
Reproductive effects (female)	30 µg/dL	Women of child-bearing capacity
Nervous system effects (child)	10 µg/dL	Individual Child
Nervous system effects (child)	5 µg/dL	Population Based Child Limit
Nervous system effects (foetal effects) during pregnancy	10 µg/dL	Pregnant women

In order to be able to put the exposure of the different groups to lead from articles in perspective, the daily uptake for different uptake routes can be compared. In the voluntary risk assessment report estimates are given for the average daily exposure of adults to lead. The dietary intake of lead by adults in the EU is between 18 and 63 µg lead per day. The average contribution of articles to the exposure is estimated to be around 2.43 µg lead per day. These figures should be compared to the current Provisional Tolerable Daily Intake (PTDI) of 250 µg lead per day. In general the reduction of dietary intake would probably have a larger effect of reducing the exposure of Europeans to lead than reduction of lead in articles. However the dietary intake is much more difficult to influence and most likely never exceed the PTDI. The uptake of lead from articles might differ strongly between one individual and another. In some cases the uptake might exceed the PTDI.

2.5.2 Impact on producers / convertors

The producers of articles containing lead would be directly affected by a ban on lead. The scope of this impact assessment report however is limited to producers of PVC products. These producers are commonly called convertors. A reduction of lead in articles would not lead to any direct effects for the convertors who make articles out of virgin PVC. The PVC convertors in Europe have already made a voluntary commitment to phase out the use of intentionally added lead stabilizers at the end of 2015. The convertors of articles that contain recycled PVC would be affected by potential lead restriction. They would be constrained in using recycled PVC that contains lead. As a result they would have no other option than to use virgin PVC, which has a higher price than recycled PVC and this would result in a financial and social impact.

2.5.3 Impact on recyclers

Recyclers of lead containing materials such as waste PVC would be affected if lead is restricted or banned. Lead in recyclable PVC waste would constrain or prevent the recycling of PVC and its subsequent use in new articles if these articles would not be allowed to contain lead. This would reduce the market for recycled PVC in Europe significantly and this would have a significant financial and social impact on the recycling industry.

2.5.4 Stabilizer producers

As lead stabilizer will be phased out by end 2015, stabilizer producers have already taken steps to gradually switch to other stabilizer systems. A ban on lead in articles would have hardly an effect on stabilizer producers.

2.6 How would the problem evolve, all things being equal?

Purpose of stabilizers

Lead based stabilizers are added to PVC resin in order to stabilize[1] PVC. The PVC resin together with stabilizer and other additives is called the compound. The stabilization effect takes place during production, when the compound is heated to produce its final form, as well as during the life of the article. In the latter case the lead protects the article against deterioration due to light and high temperature.

Lead stabilizers

Lead stabilizers were in many applications the preferred stabilizer because of their efficiency, well mastered technology and favourable cost/performance. The PVC industry has taken ownership to phase out the use of lead stabilizers in PVC by the end of 2015 [Vinyl2010]. However this takes some time as a change of stabilizer means changing the whole production process.

[1] Lead has been used as a pigments in PVC as well as a stabilizer. The amount of lead as a pigment is usually much lower than the amount of lead used as stabilizer. For more information about pigment and stabilizer see Annex 1

By the end of the first quarter of 2013 about 80 % of the volume of lead stabilizers used in the EU in 2000 has been replaced by alternative stabilizers. This means that beyond 2015 no additional lead will be added to the stock of lead contained in PVC articles present in society.

Legacy lead and recycling

PVC has been used for about 6 decades now. As PVC articles generally have a long lifespan (e.g. window frames) PVC waste emergence is increasing now. This is reflected by the increase of post-consumer PVC recycling recorded by Vinyl 2010/VinylPlus. The recorded amount increased from 16,000 metric tons in 2005 to 254,814 metric tons in 2010 [Vinyl2010_progress report]. The recycled amount is expected to increase further in the years to come. This means that part of the lead containing PVC present in society is taken out of the stock and after recycling is added to the stock again. However as there is always some loss of material during the recycling operations, part of the lead contained in PVC will be removed from stock and will be disposed of, either in an incineration facility or in landfills. As no new lead is added to the stock after 2015 and lead continues to be removed through disposal, the total amount of lead in PVC products in stock in society will decrease. Furthermore as nearly all articles made from recycled PVC also contain some virgin PVC, the lead content in PVC articles will go down in time, thereby reducing the exposure of humans and the environment to lead. Because of the long lifespan of most PVC articles the amount of lead in PVC in stock in society and the concentration of lead in PVC articles will decrease slowly with time (see simulations in Appendix 7).

Current lead restricting legislation

There is no general regulatory ban on the use of lead in PVC articles; there are however specific applications where lead has been restricted, such as in packaging, automotive components, children’s toys and electrical and electronic equipment. The European PVC industry has committed itself to phasing out the use of intentionally added lead stabilizers for the European market by the end of 2015, however convertors outside of the EU can make PVC products and will not be bound by the voluntary commitment. As things stand now imports of lead containing PVC are legally permitted. The total amount of imported PVC products compared to the total amount of PVC products made in Europe is assumed to be limited though. This might not be the case for some specific types of PVC articles, such as toys and clothing which are mainly imported from the Far East.

Conclusion

Without European intervention no new lead will be added to the stock. PVC waste recycling will continue as it does at this moment, which means that recycling will grow with the PVC waste arising. The use of recycled PVC in specific applications will remain forbidden through specific legislation.

2.7 EU right to act

The most obvious place for legislative actions that could be taken to restrict the use of lead in products would be in the REACH regulation. The restriction of lead in PVC products could be included in Annex XVII of the REACH regulation.
The purpose of this Regulation is to ensure a high level of protection of human health and the environment, including the promotion of alternative methods for assessment of hazards of substances, as well as the free circulation of substances on the internal market while enhancing competitiveness and innovation.

If the European Union wishes to protect the environment and human health from lead pollution, while at the same time keeping a level playing field and retaining the possibility of PVC recycling, action should be taken at European level. Besides, European action is required in order to keep the circulation of articles free within the European Union. A potential regulation of lead in products is not expected to change the EU budget.

2.8 Consulted literature for chapter two

[Vinyl2010] Vinyl 2010: The Voluntary Commitment of the PVC Industry, Update May 2006, Accessible at: http://www.vinyl2010.org/images/stories/2006/Vol%20Com%202006%20Eng.pdf

[Vinyl2010_progress report] Vinyl 2010: 2011 Progress Report, reporting on the activities of 2010 and summarizing the key milestones of the past 10 years, Accessible at: http://www.vinyl2010.org/images/progress_report/2011/vinyl2010_progress_report_2011_final.pdf

[EFSA] European Food Safety Authority; Lead dietary exposure in the European population. EFSA Journal 2012; 10(7):2831. [59 pp.] doi:10.2903/j.efsa.2012.2831. Available online: www.efsa.europa.eu/efsajournal

[VRAR] Voluntary Risk Assessment Report on lead and some inorganic Lead Compounds, Lead Development Association International, March 2008

[WHO] WHO, ENHIS: Levels of leaf in Children's blood, Factsheet 4.5 December 2009, code: RPG4_Chem_Ex1.

[COWI] COWI Consulting Engineers and Planners on behalf of Nordic Council of Ministers, Lead Review, January 2003

3 Objectives

3.1 Introduction

This chapter describes the objectives of possible European policies to be implemented as they are assessed in this study.

3.2 What are the general policy objectives?

The general objectives of a policy on the restriction on lead in articles would be:

1. To enhance human health by limiting the exposure of humans to lead
2. To enhance the environment by limiting the exposure of the environment to lead

At the same time try to not to hinder recycling as laid down in the EU waste policy.

3.3 What are the more specific/operational objectives?

The operational objectives of a policy are:

1. Improve human health by reducing the exposure to lead by minimizing the amount of lead in articles
2. Reduce the amount of lead released in the environment by minimizing the amount of lead in articles
3. Enable recycling of lead containing PVC waste in a cost-efficient and environmentally friendly way
4. Back up the European PVC industry programme in phasing out the addition of first intent lead-based stabilizers in PVC articles

4 Policy options

4.1 Introduction

This chapter describes the policy options that could be implemented to limit the exposure of humans and the environment to lead. The options are given in a general way, that is, for all articles, whereas the rest of this study focuses on the impact of any lead regulation on PVC articles. The options are screened for feasibility in this chapter. Only the most feasible options will be analyzed further in chapter 5. All identified options are summarized below.

Option 1: No change in current EU regulations
Option 2: Restriction of lead content in all articles with a 0.1 % limit concentration
Option 3: Restriction as in 2 with exemption of building products
Option 4: Restriction as in 2 with 1 % restriction limit for building products
Option 5A: Restriction as in 2 with exemption for building products for a limited time
Option 5B: Restriction as in 2 with 1 % restriction limit for building products for a limited time
Option 6: Restriction of lead content with a 0.1 % limit concentration in directly accessible parts of articles
Option 7: Restriction of lead content with a 0.1 % limit concentration, with exemption when the leaching is proven to be below a certain limit value
Option 8: Non regulatory option: Voluntary measures by PVC recyclers and PVC converters

During this impact assessment study another option was put forward by the Swedish chemical agency. This option cannot be properly assessed in this study as the scope of the restriction is unclear. For the sake of completeness this option has been described in this chapter:
Option 9: Restriction of lead and its compounds in articles intended for consumer use.

The following paragraphs describe the nine policy options into more detail.

4.2 Option 1: No change in current EU regulations

This option is the business as usual (BAU) option or the reference situation. The use of lead is no further restricted than is the case at this moment. This means that only certain lead compounds in artistic paint would be restricted through the REACH regulation as well as lead and its compounds in jewellery. The lead content in certain products is further restricted only by the recast RoHS directive for electric and electronic equipment, the Packaging Directive and Packaging Waste directive, the Toy Safety Directives as well as by the ELV directive for automobile vehicles. Further the voluntary commitment of the PVC industry as described in the Vinyl 2010 and VinylPlus program will be executed. This means lead will be replaced as a virgin stabilizer in PVC by the end of 2015. Besides the regulation and the voluntary commitment, lead use has been discontinued since 2007 on a voluntary basis in drinking water pipes the whole of the EU. PVC waste which contains lead would be reused in new products however without any restrictions with the exception of the PVC used in electric and electronic devices, packaging, toys and in the automobile industry.

4.3 Option 2: Prohibition of lead in articles >0.1 %

In this option it would be prohibited to put on the market articles containing chemical lead compounds, when the content of lead in the article's homogenous individual parts is greater or equal 0.1 % by weight.

As lead stabilizers cannot stabilize PVC in a satisfactory way at concentrations below approximately 0.75 % the threshold of 0.1 % would effectively lead to a stop in the intentional addition of lead based stabilizers. Recycling would be severely constrained as well because the average content of recycled PVC generally exceeds this threshold. In order to make a product with a lead content well below the threshold no more than a maximum of approximately 10 % recycled post consumer PVC could be used. The average amount used in window profiles made of recycled PVC is around 40% and in piping made with recycled PVC is 65-100 % at this moment. If only 10 % of recycled PVC could be used in an article convertors would not use recycled PVC as the lower price of recycled PVC compared to virgin PVC would be more than offset by the more expensive machinery and lower throughput. Economically it would just not be viable.

4.4 Option 3: Prohibition of lead in articles >0.1 % with exemption for use of recycled material in building products

This option is comparable to option two except that an exemption is made for building products, when these building products are made using recycled materials. Building products are defined in the Construction products directive [REGULATION 305/2011] as follows:

‘construction product’ means any product or kit which is produced and placed on the market for incorporation in a permanent manner in construction works or parts thereof and the performance of which has an effect on the performance of the construction works with respect to the basic requirements for construction works;’

For the purpose of this study drinking water pipes are excluded from the definition of construction products and thereby from the exemption of lead restriction. The reason for this exclusion is that drinking water pipes usually do not contain recycled material because of the restriction in the Reach regulation for the use of cadmium in drinking water pipes. Besides the use of lead free drinking water piping is common practice in Europe, as the European producers of piping have voluntarily switched to other stabilizers in 2007.

PVC building products which are made using recycled PVC shall be produced without adding new lead stabilizers. In this option building products would be exempted because building products are the products in which recycled PVC is normally used, thus making recycling viable. At the same time emission of lead from building products is assumed to be very low as building products are often shielded by a covering material as is the case with most piping and window profiles. Besides, many building products, like window profiles and flooring materials, have an external layer of virgin material.

For this option we assume that a comparable wording would be used as is being used for the restriction of cadmium and the associated exemption for recovered PVC containing cadmium in the Reach regulation, without the limiting concentration in paragraph 4. See option 4 for the exact wording.

4.5 Option 4: Prohibition with an exemption for use of recycled material in building products with a 1 % restriction limit

This option is comparable to option three except that the building products made of recycled material would have a maximum lead content of 1 % instead of an unlimited lead content.
The applicable wording in the Reach regulation would be:

Lead
1. shall not be used in mixtures and articles produced from the following synthetic organic polymers (hereafter referred to as plastic material):

- *Polymers or copolymers of vinyl chloride (PVC)*
- *(…)*

Mixtures and articles produced from plastic material as listed above shall not be placed on the market if the concentration of lead (expressed as Pb metal) is equal to or greater than 0.1 % by weight of the plastic material.

(…)

3. By way of derogation, paragraph 1, second subparagraph shall not apply to:

- *Mixtures produced from PVC waste, hereinafter referred to as 'Recovered PVC'*
- *Mixtures and articles containing recovered PVC if their concentration of lead (expressed as Pb metal) does not exceed 1 % by weight of the plastic material in the following rigid PVC applications:*
  Building materials as defined in REGULATION (EU) No 305/2011 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 9 March 2011, with the exception of pipes for drinking water.

4.6 Option 5: Prohibition with an exemption for use of recycled material in building products, without a restriction limit or with a 1 % restriction threshold, until a review date

This option is split into two options that differ in the allowed amount of lead in building materials made of recycled material. Both options have in common that the exemption is limited in time. After a specified time the exemption is reviewed. The options are:

Option 5A. This option is comparable to option three: A prohibition of lead in articles with an exemption for lead in building products; however the exemption would be reviewed after a specified limited time.

Option 5B. This option is comparable to option four: A prohibition of lead in articles with an exemption for lead in building products with a maximum lead content of 1 %, however the exemption would be reviewed after a specified time.

The principle of a time limit is comparable to the time limit for the derogation of cadmium in the REACH regulation where the derogation would be reviewed by a certain date.

4.7 Option 6: Prohibition of lead in directly accessible parts of articles

In this option instead of a full prohibition of lead in articles a prohibition is put in place for lead in the surface of an article made of recycled material. The reasoning behind this option is that the exposure of people to lead is negligible if the lead is only inside an article instead of on the outside. The use of new lead stabilizer is still prohibited; therefore lead in new articles can only be a result of recycled material. For cadmium this principle has been applied for piping except drinking water piping. However this approach would be very difficult for most different types of PVC products other than piping. For instance fittings for piping cannot be made this way because they are moulded instead of extruded. The definition of directly accessible is prone to discussion. For example: Should it be tested in the situation when an article is installed or when you buy it in a shop? How to interpret this when an article in contact with any medium that could extract the lead? Are ventilation slits allowed, and at what size?

4.8 Option 7: Prohibition with exemption when leaching is below a certain limit value

In this option a product can be put on the market if the producer can prove that leaching of lead from the product is so low that the human health and the environment is not jeopardized. This option is not very practical as this might lead to discussion about the amount of lead allowed to leach from products, the uptake by humans and the leaching into the environment. At least it might lead to repeated testing of products and difficulties in enforcing a regulation. Testing procedures might have to be developed as they do not exist at this moment for specifically testing of PVC articles. Development of testing procedures usually takes years.

4.9 Option 8: Non regulatory option

The Guideline for impact assessment states that the initial set of options should include at least one non regulatory option or a self- and co-regulation option. The prominent EU partner for a non regulatory option in the PVC sphere is VinylPlus. The PVC industry united in the VinylPlus commitments has already taken steps to gradually phase out the use of lead based stabilizers in PVC products. By the end of 2011 already 71% of the lead stabilizers used in 2000 had been replaced by other stabilizer systems in the EU27. Total phase out will be achieved latest by end 2015. Going further to reach the objective of reduced exposure to lead by forging an agreement with Vinyl Plus is assumed to be difficult. The European Plastic Converters known collectively as EuPC, who are a founding partner of VinylPlus, have most influence on the recycling of PVC and any lead problems involved. However dialogues with EuPC aiming to stop the recycling of lead containing PVC would probably be difficult to negotiate as discontinuing lead containing PVC waste recycling could have a significant business impact. Besides not all convertors are member of EuPC so they would not be bound by a self regulation contract between EuPC and the EU.

4.10 Option 9: Restriction under REACH Annex XVII of lead and its compounds in articles, which can be placed in the mouth by children, and which are made available for consumers or intended for consumer use.

The Swedish competent authority filed a proposal to restrict the use of lead and lead compounds in articles intended for consumer use. The text in the Registry of submitted Restriction proposal intentions is given below [ECHA].

The proposed restriction is worded as below:
Lead CAS No 7439-92-1 EC No 231-100-4 and its compounds
1. Shall not be placed on the market or used in articles or individual parts of articles, which are supplied to the general public and which can be placed in the mouth by children, if the concentration of lead (expressed as metal) in that article or part of article is equal to or greater than 0,05 % by weight.

2. For the purposes of paragraph 1, "individual parts of articles" shall mean such individual parts of articles that are detachable, protruding or by other means accessible to be placed in the mouth by children.
3. Paragraph 1 shall apply without prejudice to the restriction in entry 63 of this Annex.
4. By way of derogation, paragraph 1 shall not apply to:
(i) keys and locks, including padlocks
(ii) musical instruments
5. By [entry into force date + 5 years], the Commission shall re-evaluate the exemptions in paragraph 4 in the light of new technical information, including the availability of alternatives, and if appropriate modify this entry accordingly.

"General public" as used in the text of the Swedish competent authority is not clearly defined in REACH regulation. However REACH differentiates between industrial use, professional use and consumer use. In the guidance documents these are referred to as the three main user groups. It can be assumed that the "general public" and "consumer use" are meant to be the same.

An advantage of this option would be that the group deemed to be most vulnerable, namely children, would be better protected from lead exposure. In the case of PVC it would not significantly hamper recycling as most recycled PVC is used in building products where average risk of human exposure to lead via putting in the mouth can be assumed to be zero [VRAR].

At this moment no data are available for all applications that could be put in the mouth of children. Therefore a quantification of impacts cannot be made. Besides the scope of the proposal is until now not very clearly defined. As the proposal was only recently put on the table, the effects have not been studied extensively.

4.11 Options to be analyzed further

Of the nine options described in the preceding paragraphs options 1, 2, 5B and 9 will be investigated further. Option 3, 4, 5A, 6, 7 and 8 are given no further consideration at this stage. The following reasons are given for putting aside these options:

- Options 3 and 4 are not limited in time. This is not consistent with the ultimate objective to minimize lead in articles. The lead content would as a result of the phase out of lead stabilizers decrease in time until a concentration below 0.1 % is reached. Allowing lead in a higher concentration after the lead content would naturally decline below 0.1 % is counterproductive as this would leave an opening for the use of lead in articles by foreign convertors not bound by the voluntary commitment. The effectiveness of the option is therefore low. Besides options 3 and 4 could be considered as a special case of options 5A end 5B

- Options 3 and 5A have no upper limit for the amount of lead in articles. This way there is no incentive to reduce the amount of lead in articles. Recycled PVC granulate with high lead content could be imported into the EU and used to produce new articles with a high lead content. This is not consistent with the aim of reducing the exposure to lead. The effectiveness of the option is therefore low
- Option 6 is given no further consideration because this option is only applicable for extruded or multilayer products. All other production processes would be automatically excluded from use of recycled material thereby reducing PVC recycling. Besides, it might give rise to discussion over the definition of “accessible”. The option therefore is not very efficient as it might lead to legal uncertainty and therefore might result in high costs or no recycling because convertors choose to stay on the safe side
- Option 7 is given no further consideration because the enforcement of the regulation is difficult. Setting a leaching limit value could lead to extensive discussions about testing and the allowable amount of lead to leach out. Testing could be costly, difficult and might be unreliable and it would take many years to develop testing methods. The option therefore is not very efficient as it might lead to high testing costs
- Option 8 is given no further consideration as the stakeholders involved would have to bind themselves to a bilateral agreement which would hinder them in their core business. The parties involved are unlikely to bind themselves to such an agreement as it might result to impact the business of their companies. In addition, it would be difficult to enforce and would not prevent import of PVC products containing lead. This option therefore is not very effective
- Option 9 is given no further consideration as the scope of the restriction is not clearly defined. The enforcement would be difficult. As the scope is not clear, the results of the impact assessment would be disputable. Besides this option was only put on the table recently and therefore could not be researched extensively

Removing theses options from the list results in a short list to be further analyzed in this impact assessment study. The options left to be studied are:
- Option 1: No change in current EU regulations
- Option 2: Prohibition of lead in articles >0.1 %
- Option 5B: Prohibition with an exemption for use of recycled material in PVC building products, with a restriction limit of 1 %, until a review date

4.12 Consulted literature for chapter four

[REGULATION 305/2011] REGULATION (EU) No 305/2011 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 9 March 2011 laying down harmonised conditions for the marketing of construction products and repealing Council Directive 89/106/EEC

[ECHA] ECHA website, registry of current Restriction proposal intentions: Lead and lead compounds in articles intended for consumer use, http://echa.europa.eu/registry-of-current-restriction-proposal-intentions/-/substance/1402/search/+/term accessed January 17th 2013

[VRAR] Voluntary Risk Assessment Report on lead and some inorganic Lead Compounds, Lead Development Association International, March 2008

5 Analysis of impacts

5.1 Introduction

In this chapter the impacts of the three options that were identified in chapter 4 are analyzed further. This is done in two steps. First the impacts are identified and classified in a qualitative way. This is described in paragraph 5.2. The impacts with the highest consequences will be analyzed quantitatively in step two which is described in paragraph 5.3.

5.2 Identification of impacts and qualitative analysis

In order to identify the impacts of the different options tables 1, 2 and 3 in chapter 8 of the impact assessment guidelines (SEC(2009) 92) have been used. By filling in these tables a first screening is made of the possible impacts. The impact is based on two factors: likelihood and magnitude. The screening was made based on common sense of the researchers and input from stakeholders in the PVC industry. The purpose of these tables is to identify the theoretical biggest impacts and have only been used as a step in the impact assessment process. As they are used only to screen options the statements in the tables are based on qualitative judgement. In the quantitative analysis step the real impacts of the theoretical biggest impacts have been calculated. The full tables as they have been filled in during the assessment can be found in Annex 2 to this impact assessment report.

A summary of the filled in tables with the most important impacts is given below in tables 5.1 to 5.3. In these tables only the impacts identified as “High” are listed. This is the combined result of high likelihood estimation and high magnitude estimation.

Table 5.1 Most important economic impacts of policy options 2 and 5B

Question	Impact description	Impact of Option 2	Impact of option 5B
Will it lead to new or the closing down of businesses?	As the demand for secondary material might fall some recyclers would be severely impacted. Export of PVC waste would most likely increase.	High	Medium
Does it promote greater productivity/resource efficiency?	Lower resource efficiency. Some high lead containing material would be difficult to recycle. Lower amounts of recyclable material will be available which results in lower use of recycling capacity.	High	Medium
Does the option have significant effects on certain sectors?	Recyclers would have to take into account the amount of lead in their feedstock. Convertors cannot use as much secondary material as they want.	High	High

Table 5.1 shows the three economic impacts that result from policy options 2 and 5B with the highest consequence. In order to compare the different policy options the following variables need to be quantified.

1. How many businesses would open or close down? (#)
2. What would be the financial effect of the options? (MEUR/interval 2015 – 2050)

Table 5.2 Most important social impacts of policy options 2 and 5B

Question	Impact description	Impact on Option 2	Impact on option 5B
Does it have specific negative consequences for particular professions, groups of workers, or self-employed persons?	Negative consequences for staff working in PVC recycling. These people would probably have less work, and might become unemployed. Very limited consequences might result for people working in lead stabilizer production, and lead pigment production. Lead stabilizers are already in the process of being phased out; lead pigments have a very limited production. The lead reducing options would have a limited positive influence on the health of people working with lead and lead containing mixtures and articles. Lead uptake in occupation in the PVC production chain is mainly in the formulation stage.	High	Medium
Does the option increase or decrease the likelihood of health risks due to substances harmful to the natural environment?	Decrease the health risk.	High	High

Table 5.2 shows the impact with the highest consequence for the social impacts. In order to compare the different policy options the following variables need to be quantified.

1. What is the job reduction every year? (# of jobs every year)
2. What would be the health consequence of the policy? (# of people with a elevated blood lead level)

Table 5.3 Most important environmental impacts of policy options 2 and 5B

Question	Impact description	Impact on Option 2	Impact on option 5B
Does the option affect the emission of greenhouse gases (e.g. carbon dioxide, methane etc.) into the atmosphere?	Yes, for the production of virgin resin more oil and/or energy are necessary compared to secondary material. Banning lead would result in limiting recycling. PVC waste would then have to be incinerated, leading to more CO_2 emissions.	High	Medium
Will the option increase/decrease energy and fuel needs/consumption?	Increase of energy use if recycling is hampered as recycling takes less energy than making virgin material. A small compensation comes from incinerating PVC.	High	Medium
Does it reduce or increase use of non-renewable resources (groundwater, minerals etc.)?	Because recycling would be less, increase of the use of non-renewable resources, crude oil and salt.	High	Medium
Does the option affect waste production (solid, urban, agricultural, industrial, mining, radioactive or toxic waste) or how waste is treated, disposed of or recycled?	No increase or decrease in waste produced. The waste treatment is changed a lot. No more recycling (in policy option 2). Maybe more export? Possibly more landfilling and incineration.	High	Medium

Table 5.3 shows the impact with the highest consequence for the environment. In order to compare the different policy options the following variables need to be quantified.

1. How much extra CO_2 would be emitted compared to the BAU option? (tonnes of CO_2-emissions in interval 2015 - 2050)
2. How much more or less energy would be used compared to the BAU option? (MJ)
3. How much more or less crude oil/natural gas/condensate/coal/lignite and NaCl would be used compared to the BAU option? (tonnes of crude oil/natural gas/condensate/coal/lignite and tonnes of NaCl consumed because of non recycling (landfilling and incineration)
4. How much waste is recycled, incinerated, landfilled and exported? (tonnes per disposal/recovery option)

5.3 Quantitative analysis

In the preceding paragraph questions were formulated for indicators of the impacts. This paragraph gives the answers to the questions posed in paragraph 5.2.

The basis for the impact assessment is a model calculation concerning recycled volumes of PVC and the lead concentration in new PVC products. These model calculations are described in more detail in annexes two and six. In short the calculations were done as follows.

Calculations are based on the Dynamic Waste Analysis tool of EuPC. This model gives waste arising and expected production data per application as well as the amount of lead containing waste. Data from the EuPC model were supplied to the researchers by EuPC. From the total waste arising and the lead containing part of the total waste the lead concentration was calculated in the total waste per application. The lead concentration in new articles was calculated as well for the different applications.

As an example of the calculations the lead concentrations in the piping waste and the new pipes and fittings made of recycled PVC waste from pipes and fittings have been plotted against time in figure 5.1. The rest of the results of these calculations can be found in appendix 7.

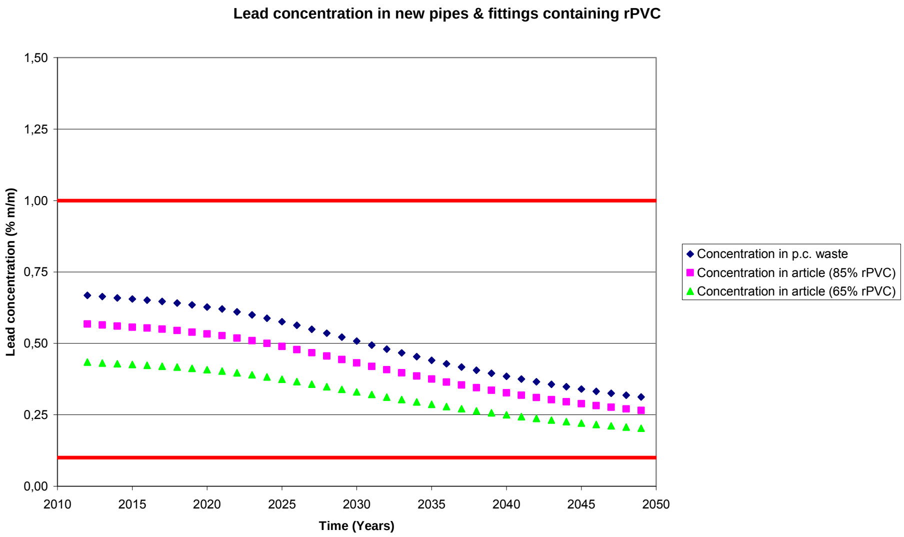


Figure 5.1 Example of the results from the concentration calculations. In this case for pipes and fittings.

For the distribution over the waste management options (recycling, incineration, landfilling and export) a most likely scenario was made based on assumptions on waste management in Europe (see appendix 2). The most likely scenario was combined with the different policy options (BAU, 2, 5B) to calculate the distribution over the waste management options, recycling, incineration, landfilling and export. The result of the calculation gives the tonnes of PVC for each of the applications which would go to the different waste management options in the years from 2015 up to 2050.

In order to gain an impression of changes in the outcome as a result of changes in the real world the distribution was also calculated for different assumptions on waste management. These assumptions are based on the seventh European Environmental Action Plan. An extensive discussion of the disposal scenarios can be found in appendix 2.

The result of the calculations can be found in paragraph 5.3. The tonnes of PVC waste per disposal option are the input for the calculation of the social, environmental and economic impact of the policy options. An explanation of the calculation of the impacts is given in appendix 6.

A short delineation of the calculations and the outcomes is given in figure 5.2.

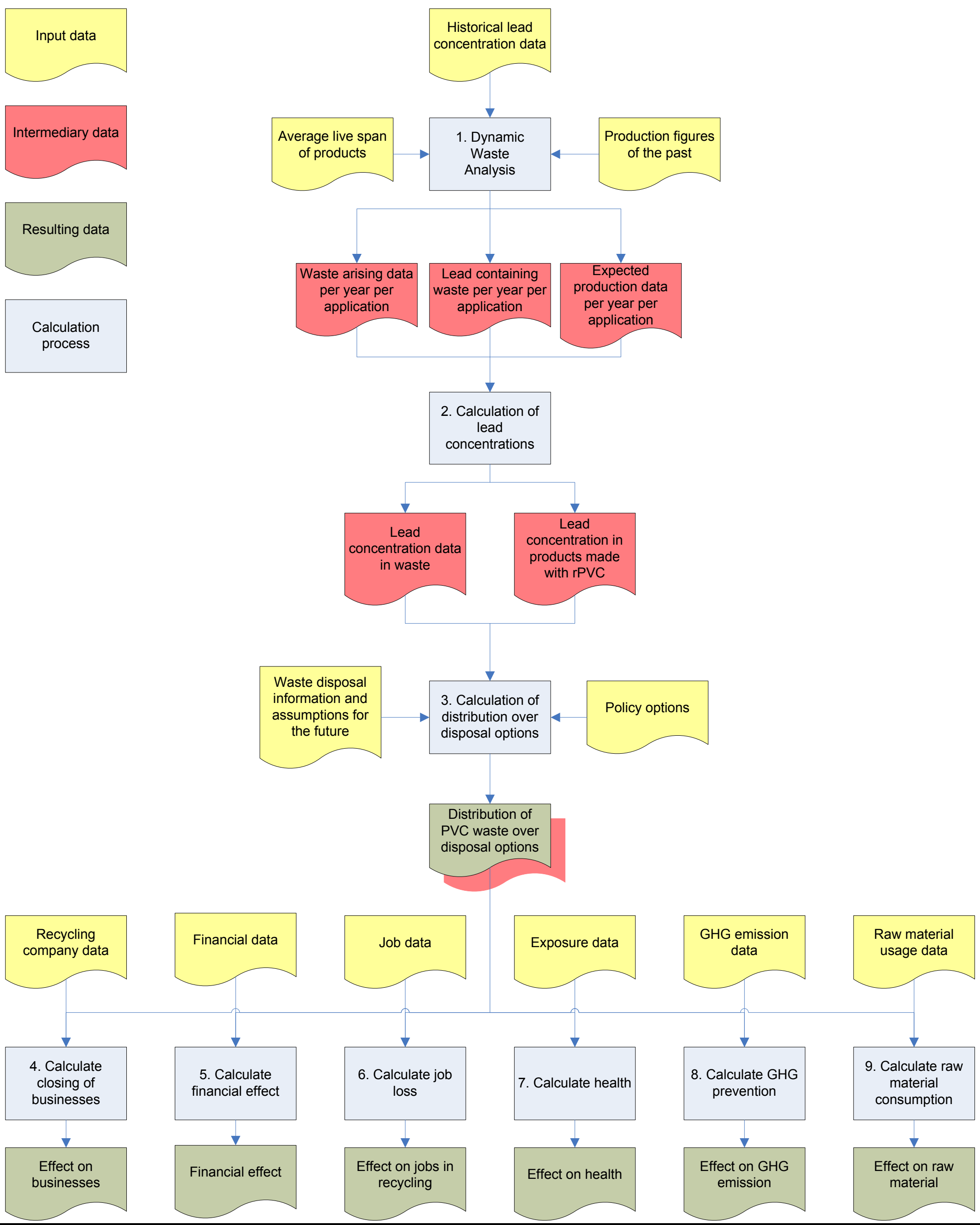


Figure 5.2 Deliniation of the calculations to arrive at the effects

5.3.1 Distribution over waste treatment options

The distribution over the waste management options was calculated as explained in appendix 2. The resulting amounts are given in table 5.4.

Table 5.4 distribution over the waste management options

Policy option	Recycling (tonne)	Incineration (tonne)	Landfilling (tonne)	Export (tonne)
BAU	14 533 267	18 001 887	1 719 665	7 340 285
Option 2	2 489 758	19 589 685	1 719 665	17 795 996
Option 5B	14 533 267	18 001 887	1 719 665	7 340 285
Option 2 EAP7	5 367 102	2 792 456	532 878	32 902 668
BAU/option 5B EAP7	30 057 324	2 792 456	532 878	8 212 445

The distribution of PVC waste among the waste management options is the same for the Business As Usual (BAU) option and option 5B. In option 2 more waste would be incinerated and exported. Recycling in Europe would decrease significantly. If the scenario of the EAP7 becomes reality and options BAU or 5B are chosen recycling would increase significantly, incineration and landfilling would be minimized and export would increase slightly. If policy option 2 is chosen material shifts from recycling in Europe to export and subsequent recycling.

5.3.2 Closing or opening of businesses as result of the policy options

Based on the average size of a recycling company and the amount of recycled PVC waste per year the number of recycling companies in Europe were calculated. These are given in table 5.5.

Table 5.5 Business closing as a result of the policy option

Policy option	Number of recycling companies	Difference from BAU
BAU	154	0
Option 2	26	-128
Option 5B	154	0
Option 2 EAP7	57	-97
BAU/option 5B EAP7	319	+165

Table 5.4 shows that option 2 results in the closing of 128 businesses. Policy option 5B gives no change compared to the BAU option. If a positive scenario for recycling is used as the basis for calculation corresponding to the proposal for the EAP7 the number of recycling companies for PVC could increase by approximately 165 in comparison to BAU. Policy option 2 in combination with the EAP7 scenario would result in closing down of 97 businesses compared to BAU.

5.3.3 Financial effect of the policy option

The financial effects of the policy options are calculated as explained in appendix 6. The results of this calculation are given in table 5.6.

Table 5.6 Financial effects of recycling of the policy options

Policy option	Added value from 2015 to 2050 [MEUR]	Difference from BAU [MEUR]
BAU	9 287	0
Option 2	1 591	-7 696
Option 5B	9 287	0
Option 2 EAP7	3 430	-5 857
BAU/option 5B EAP7	19 207	+9 920

The financial effect of policy options BAU and Option 5B are comparable. Policy option 2 shows a loss of more than EUR 7 billion compared to the BAU. In the EAP7 scenario recycling is stimulated and this results in an extra profit around EUR 10 billion up to 2050 for policy options BAU and 5B. If policy option 2 is chosen this results in a loss at a little less than EUR 6 billion.

5.3.4 Job loss/gain as a result of the policy option

The number of jobs in recycling has been calculated as explained in appendix 6. Table 5.7 shows the number of jobs every year in PVC recycling plus the jobs every year in converting as a result of using recycled material and the difference form the BAU scenario.

Table 5.7 Job loss/gain as a result of the policy options

Policy option	Jobs in recycling + jobs in converting as a result form recycling (-)	Difference from BAU (-)
BAU	968	0
Option 2	166	--802
Option 5B	968	0
Option 2 EAP7	358	-610
BAU/option 5B EAP7	2001	+1033

Table 5.7 shows a job loss of 802 if policy option 2 is enforced. Policy option 5B shows no change in the number of jobs compared to BAU. When the targets of the seventh European EAP are being met both the BAU/policy option 5B and policy option 2 would have more jobs than in the most likely scenario. However policy option 2 would still have fewer jobs than in the BAU.

5.3.5 Number of people with an elevated Blood Lead Level (BLL)

In appendix 6 it is shown that exposure to lead as a result of the lifecycle of articles made from lead containing PVC is negligible. Therefore no difference between the policy options exists. This is a result from the fact that lead is tightly bound in the PVC matrix and recycled PVC is usually applied within outer layers of virgin material as consumers want a nice coloured product without small spots of other colour.

5.3.6 Global warming potential

The global warming potential was calculated as given in appendix 6. Table 5.8 gives the amount of greenhouse gasses in tonnes CO_2-eq that is prevented by the waste processing.

Table 5.8 Global warming ptential from waste processing

Policy option	Amount of greenhouse gasses prevented (tonnes CO_2-eq)	Difference from BAU (tonnes CO_2-eq)
BAU	21 282 311	0
Option 2	14 646 419	-6 635 892
Option 5B	21 282 311	0
Option 2 EAP7	63 636 562	42 354 251
BAU/option 5B EAP7	68 245 772	46 963 461

Waste processing reduces the emission of greenhouse gasses. As recycling prevents the production of new PVC and incineration prevents burning of fossil fuel, total emissions are negative. Again BAU and Option 5B are comparable. Policy option 2 shows over 6 Mtonnes of CO_2-eq less prevention. If the EAP7 scenario becomes reality more greenhouse gasses are prevented for both BAU/option 5B and option 2. However BAU and policy option 5B still have a better score than policy option 2.

5.3.7 Energy consumption

All processes use primary energy. However when material is recycled or incinerated the use of primary energy is prevented because the production of virgin material isn't necessary and less electricity and heat has to be generated by using primary fuels. The energy consumption of the policy options was calculated as explained in appendix 6. The results of these calculations are given in table 5.9.

Table 5.9 Prevention of primary energy use as a result from waste processing

Policy option	Primary energy use prevention (MJ PE)	Difference from BAU (MJ PE)
BAU	369 467 100 209	0
Option 2	332 266 085 259	-37 201 014 950
Option 5B	369 467 100 209	0
Option 2 EAP7	420 208 846 549	50 741 746 340
BAU/option 5B EAP7	480 017 366 682	110 550 266 472

Again business as usual and policy option 5B are comparable. Policy option 2 shows a decrease in prevention of primary energy use. If recycling is stimulated as in the proposal for the EAP7 the prevented primary energy usage increases greatly. The relative differences still exist as in the most likely scenario.

5.3.8 Raw materials consumption

Producing PVC requires raw materials such as crude oil and salt. If PVC waste is going to incineration and landfilling new PVC needs to be made in order to meet the demand for new PVC products. The raw materials consumption was calculated as explained in appendix 6. The results of the calculation are given in table 5.10.

Table 5.10 Raw material consumption in the different policy options

Policy option	Raw material consumption of Oil/Gas/condensate/coal/lignite (tonne)	Raw material consumption of salt (tonne)	Difference from BAU (tonne Oil/Gas/ condensate/coal/ lignite)	Difference from BAU (tonne salt)
BAU	22 999 851	10 748 535	0	0
Option 2	24 808 272	11 681 978	1 808 420	933 443
Option 5B	22 999 851	10 748 535	0	0
Option 2 EAP7	3 891 087	1 789 659	-19 108 765	-8 958 876
BAU/option 5B EAP7	3 891 087	1 789 659	-19 108 765	-8 958 876

In the BAU and policy option 5B the same amount of PVC waste would be incinerated and landfilled. Therefore the raw material consumption for replacing the PVC material losses is the same. In policy option 2 more PVC waste would be diverted to land fill and incineration resulting in higher raw material consumption. In the EAP7 scenario more PVC waste would be recycled and exported resulting in a lower raw material consumption. In the EAP7 scenario landfilling and incineration are minimized. In our modelling we assume that any material that would be exported would also be recycled abroad. Therefore the raw material consumption is the same for all the policy options.

6 Comparison of options and conclusions

6.1 Comparison of options

In the previous chapter the impacts of the different policy options were analyzed. In this chapter a comparison is made between the policy options. The indicators for the policy options have been brought together in table 6.1.

Table 6.1 Comparison with BAU option

Policy option	# of recycling companies	Financial effect	Job loss	Health	Greenhouse gas emission	Primary energy consumption	Raw material consumption	Distribution over waste management options
BAU	0	0	0	0	0	0	0	0
Option 2	--	--	--	0	-	-	-	-
Option 5B	0	0	0	0	0	0	0	0
Option 2 EAP7	-	-	-	0	+	+	+	+
BAU/option 5B EAP7	+	+	+	0	++	++	+	+

0 is no difference from BAU, -- is a large negative effect compared to BAU, - is a negative effect compared to BAU, + is a positive effect compared to BAU, ++ is a large positive effect compared to BAU

Table 6.1 shows that for all the impact indicators of policy option 2 the result is worse than BAU, except for the health indicator which is the same. Policy option 5B gives results that are similar to the BAU option.

As an indication of the sensitivity of the calculations the EAP7 scenario has been calculated for option 2 and the option BAU/5B. The overall conclusion is the same. Policy option 5B and BAU give better results than policy option 2.

Based on this comparison policy options BAU and 5B give the best results in different scenarios. As both options have the same result for the PVC recycling industry no distinction can be made between these policy options. The need for restriction of lead in applications other than those investigated and in articles made from materials other than PVC will probably be decisive for the choice between these options. During this study lead restrictions these other applications and articles in other materials than PVC have not been investigated, therefore no statement can be made for the choice between the BAU and policy option 5B.

6.2 Conclusion

In this impact assessment we compared the policy options BAU, option 2 and option 5B. Option 2 consists of a lead restriction threshold of 0.1 % in all articles. Option 5B comprises of a 0.1% lead restriction threshold with the exemption of building products for which the restriction threshold is set to 1 %. The exemption would be reviewed when lead concentrations would have naturally lowered to below the restriction threshold. As can be seen in figure 5.1 this can take several decades. From the assessment the following can be concluded:

- Policy option 2 has more negative social, environmental and economic impact than the BAU and policy option 5B
- The impacts of policy option 5B and BAU are the same for PVC articles in the applications covered by this study
- In order to make a choice between policy option 5B and BAU, the impact of policy options on other PVC applications and on non-PVC articles must be taken into account. This is outside the scope of this impact assessment

7 Monitoring and evaluation

After policy options are adopted by the European Commission and Parliament, the policy must be enforced. In order to check if the policy achieves the targets, monitoring and evaluation should be done. This chapter looks into monitoring and evaluation.

7.1 What are the core indicators of progress towards meeting the objectives?

The objective of policy are given below

1. The first objective of the policy would be to enhance human health by limiting the exposure of humans to lead
2. The second objective of the policy would be to enhance the environment by limiting the exposure of the environment to lead

These objectives should be reached without limiting the recycling of PVC as was laid down in the European Environmental action programme.

As the present assessment shows the exposure of humans to lead from PVC articles is already minimized. Therefore limiting the exposure of humans to lead from PVC articles need not be monitored. However as the policy options limit the amount of lead in all articles it is recommended to monitor blood lead levels in the European population.

As lead from PVC articles hardly leaches at all, and leaching will be even less in articles containing recycled PVC, there is no need to monitor the exposure of the environment to lead from PVC articles. However as the policy options limit the amount of lead in all articles it is recommended to monitor the release of lead in the environment.

Monitoring of the recycling is already executed by VinylPlus. Information of this monitoring can be used in order to adjust the policy if necessary.

7.2 What is the broad outline for possible monitoring and evaluation arrangements?

The policy options hardly need any monitoring for PVC articles as exposure of humans and the environment to lead from PVC articles is negligible. Besides the PVC industry already gathers information about recycling. This information could be used to adjust policy. In order to be able to make a well informed review after a set time it would be good to monitor the lead concentration in recycled PVC waste. As lead is also present in other articles a European Blood Lead Level survey could be undertaken at regular intervals.

Appendix

1

How did lead get into PVC?

A1.1 How did lead get into PVC products?

Lead compounds can be used for two reasons in PVC products. The first reason is to stabilize the PVC product. The second is to colour the product. A short description of both types of additives is given below.

PVC can degrade under influence of heat or UV light. Heat is used during the production process to melt the PVC in order to be able to form the desired article. Some PVC articles receive a lot of UV light during their lifetime, therefore they must be stabilized in order to maintain the correct properties. When PVC is under the influence of heat or UV light a chlorine atom can be released from the PVC chain. This chlorine can react with hydrogen to form hydrochloric acid. This in turn can react with PVC to release another chlorine atom, thus resulting in a chain reaction. The lead stabilizer reacts with hydrochloric acid liberated during PVC degradation to form lead chloride. By "catching" the hydrochloric acid the degradation is slowed down. There are many types of lead stabilizers such as tetra-basic lead sulphate, tri-basic lead sulphate, di-basic lead phosphite, di-basic lead phthalate, di-basic lead stearate, neutral lead stearate. In recent years lead stabilizer has been replaced by other stabilizers, most notably Ca/Zn stabilizers [PVC Handbook]. The European PVC industry has made a voluntary commitment to phase out lead in their products before 2015 [Vinyl 2010]. At the end of 2011 already 71 % of the lead stabilizer volume of 2011 had been replaced with other types of stabilizers.

The second reason to add a lead compound to PVC products is in order to colour it. In the past lead based pigments, such as lead chromate, were sometimes used to obtain a specific colour. Most lead containing pigments have been discontinued. For example: lead chromate is a very toxic colorant whereof the use has already been mostly discontinued. It will be subject to authorization. Latest application date is 21 November 2013. The sunset date is 21 May 2015 [REACH].

A1.2 Which products contain lead?

Not all products made of PVC contain lead, owing to technical or regulatory constraints:

- Technical limitations: transparent material cannot contain lead stabilizer. Lead stabilizer cannot be used in flooring that contains sulphur as this would result in staining
- Regulatory limitations: restrictions in some countries or categories of articles, in drinking water pipes, children's toys, food contact packaging and E&E appliances

Therefore it is difficult to assess the impact of lead in all the different applications. The assessment is restricted to the following PVC articles which are deemed to have the largest impact:

1. Profiles
2. Pipes and fittings
3. Flooring
4. Roofing
5. Cable jacketing/sheathing

The first four items in the above list are products that in general can contain recycled material originating from post consumer PVC waste. As post consumer waste can contain lead these products will in practice contain lead if they are made of recycled material. Cable jacketing/sheathing in general contains no recyclate from post consumer waste as this might lead to shortcuts of electrical current. As waste PVC from cables has been stabilized with lead and is being used in other articles, it is an application of interest for this study.

Appendix

2

Waste management of PVC

A2.1 Introduction

The impacts of PVC waste management are influenced by the routes which PVC waste takes. The waste management options for PVC waste are landfilling, incineration (waste to energy) and recycling. PVC waste may also be exported out of the EU to be recycled abroad. A main question is how much PVC is treated per waste management option. Due to European policies and the efforts of the PVC sector there is a general switch from landfilling to incineration and recycling. In this annex we describe the main developments taking place and the assumptions on which the Impact Assessment is based. Paragraph 2 shortly describes the waste management options. In paragraph 3 the developments per option are discussed. In paragraph 4 we arrive at the two prognoses for the ratio between the waste management options used for further calculations for the Impact Assessment. Paragraph 5 and 6 discuss the potential to remove lead from PVC waste and the feasibility to separate lead containing from lead free PVC waste.

A2.2 PVC waste management options

Four waste management options can be identified for PVC: Recycling, incineration, export and landfilling. This paragraph describes the four waste management options.

A2.2.1 Recycling

The recycling of PVC has been boosted by the Vinyl2010/VinylPlus initiative. Whereas a certain amount of recycling already took place, the recycling results have improved significantly in the past years. Different types of PVC are very suitable for recycling. In various Member States collection schemes have been put in place to recover high quality PVC for recycling. In other instances PVC must be recovered from mixed waste streams through sorting. Important schemes for recycling are for instance:

- ReWindo (www.rewindo.de)
- Roofcollect (www.roofcollect.com)
- Recofloor (www.recofloor.org)
- BIS (www.bureauleiding.nl/kennisdossier/BIS/)

The increase in recycling between 2005 and 2010 can be found in the following table, taken from the VinylPlus 2011 Progress Report.

Recovinyl registered recycled volumes per country						
	Year 2005*	Year 2006*	Year 2007*	Year 2008*	Year 2009*	Year 2010*
Austria	-	-	-	4,398	3,815	4,616
Belgium	1,500	2,739	1,954	3,462**	5,493**	5,141
Czech Republic	-	-	1,165	5,858	13,685	16,464
Denmark	-	-	2,896	2,586	2,445	2,923
France	2,000***	7,446	13,276	16,943	10,890	17,377
Germany	-	5,522	35,927	77,313	71,081	92,242
Hungary	-	-	256	804	538	617
Italy	-	828	4,252	16,115	15,681	16,417
Netherlands	4,500	10,972	8,959	10,731	10,009	16,909
Poland	-	-	475	3,518	7,648	13,227
Portugal	-	-	-	477	903	1,437
Romania	-	-	-	-	-	27
Slovakia	-	-	-	-	994	1,959
Spain	-	2	-	6,293	9,093	14,838
Sweden	-	94	-	-	-	1,277
UK	8,000	17,087****	42,162	42,895****	33,963	49,343
TOTAL	**16,000**	**44,690**	**111,322**	**191,393**	**186,238**	**254,814**

* Actual figures in tonnes
** Belgium figures include the ones from Luxemburg in 2008 and 2009
*** This volume was recycled by PVC Recyclage, now included in Recovinyl
**** UK figures include the ones from Ireland in 2006 and 2008

Figure A2.1 Mass of recycled PVC per country in the years 2005 - 2010

When regarding recycling, a distinction should be made between rigid and plasticized PVC waste. Rigid PVC waste can be recycled using a relatively simple process: Grinding, and if necessary melt filtration and regranulation. The recycled rigid PVC waste is to a large extent reused in the original application, e.g. profiles and piping. A smaller percentage is used in other applications. For example 19 % of the profiles recycled are being used in piping.

Flexible or plasticized PVC however is usually more difficult to recycle as flexible PVC waste usually contains other materials such as PET fibres, PE and copper or is part of a laminate such as in flooring. When recycling flexible PVC waste the recycled material usually isn't reused in the original application (flooring,   and cables). Plasticized PVC is mainly reused in shoe soles, garden hoses, waterproofing membranes, non-residential flooring, and for traffic management products such as cones and speed bumps.

A2.2.2 Incineration

Incinerating waste reduces the volume of the waste and energy liberated during incineration can be used to generate electricity or used for heating. However, when PVC is incinerated, it might lead to more waste mass than the amount of PVC to be incinerated. This is a result of the emissions arising when burning PVC [Bertin, TNO_incineration]. The most important emission is HCl or hydrochloric acid. In order to remove the HCl, neutralization chemicals are added in the Air Pollution Control (APC) system. Depending on the APC system this might result in a little less to a maximum of 1.5 times as much waste than the original amount of PVC waste. The APC residue usually contains many different species including heavy metals. Therefore the APC residue is considered hazardous waste.

Pure PVC waste usually is not accepted at waste incinerators. There are three reasons for this:

1. PVC has a relatively high calorific value of PVC compared to normal municipal waste, thereby limiting the throughput of the oven.
2. The liberation of too high amounts of HCl, which might damage the furnace
3. The arising of APC residue

Usually a maximum concentration between 0.5 to 1.5 % of PVC in MSW is accepted though it is difficult to enforce these maximum concentrations. A higher concentration might be acceptable at some incinerators, though the acceptance would come at a premium.

A2.2.3 Export

If PVC waste is exported from the European Union to a third country, two different situations should be distinguished. The first situation is when the PVC waste is exported separately from other wastes. In this case the PVC waste will most likely be recycled. Why else would somebody bother to separate the PVC from other wastes and ship it abroad? Such PVC waste has a positive value so it is unlikely that the material will be dumped or burned in uncontrolled conditions.

The second situation is when the PVC waste is mixed with other wastes. In that case it is unknown what will happen. It might be that only one of the components of the mixture will be recycled, and that the rest of the components, including PVC waste will be disposed of. This could be for example when PVC is present in the mantle material around a copper cable. When the cables are exported they might end up in a facility where the mantle is separated from the copper. The copper will be recycled and the PVC will probably be recycled as well. In some cases however, the cables might be burned in the open air to remove the mantle and recover the copper. This might lead to uncontrolled emissions to the environment.

A2.2.4 Landfilling

The most used method of disposing of PVC wastes in Europe is still landfilling. At this moment this is the most cost effective method of disposing of wastes in many EU countries, however it brings with it some environmental drawbacks. First of all landfilling withdraws surface from usable land area. The surface will be used for indefinite years. Second, pollutants might leach from PVC products. Although rigid PVC products show almost no leaching at all, some flexible PVC products can leach pollutants. And even though PVC is relatively inert, in the long term after multiple centuries or even millennia, even PVC will deteriorate. Any polluting species within the PVC matrix might be liberated and emitted into the environment. Because landfilling has its drawbacks, and it is a waste of valuable resources, the European waste policy is aiming to minimize landfilling in favour of other options such as recycling and energy recovery. Extensive information on leaching of lead out of PVC products in landfills can be found in [TuTech and Argus]

A2.3 Trends in PVC waste management

There are several major developments that govern the management of PVC waste. These trends re-enforce each other for the most. First of all recycling of PVC is expected to further increase in the EU. This is for a major part due to the efforts of VinylPlus. Moreover, EU policy and legislation are strongly pushing resource efficiency. As a consequence there will be more focus and initiatives on recycling.
In the second place the capacity of incineration in the EU will continue to grow. As a consequence of the EU policy to divert waste from landfills Member States invest in incineration capacity. Although this is primarily aimed at the management of household waste, the result will be that also other types of waste will be offered for incineration. It is uncertain how much PVC will be sent to incineration instead to landfills. Other aspects such as landfill taxes also influence the route which the waste will take. As a point of departure and as a matter to define scenarios, we assume in the following that relative increase in incineration capacity also leads to a relative shift of PVC waste from landfill to incineration.
In the third place the demand for raw materials will increase in developing countries. This might lead to an increase in export of PVC waste.
Lastly landfilling is discouraged under the Landfill Directive and landfilling is defined as a disposal option which is set as the last option in the Waste Framework Directive hierarchy. This paragraph gives more background on these trends.

A2.3.1 Recycling

In 2010 some 250,000 tonnes of PVC waste were recycled as recorded by VinylPlus. Most likely a higher amount was recycled but not all recycled PVC was recorded by VinylPlus. The sharp increase compared to earlier years will not continue for the next decades. According to the EuPC model the PVC available post-consumer PVC waste arising in 2010 would be 2.49 million tonnes. The recycling ratio therefore amounts to 10 %. VinylPlus has made a commitment to recycle 800 ktonnes of PVC in 2020. Of these 800 ktonnes about 500 ktonnes are expected to be recycled from post consumer waste. This would mean a recycling ratio around 20 %. This is approximately the same as the expected achievable recycling ratio of post consumer waste around 20 % in the Netherlands [Tauw, 2011].

A2.3.2 Incineration

Ecoprog [Ecoprog, 2012] has recently made an inventory of the global capacity of waste incineration. In the period 2007-2012 the worldwide capacity increased by 12 %. Until 2016 the capacity is expected to increase by 16 %. This is for instance due to large investments in countries like the UK and China. [Manders, 2010] at an earlier stage concluded that the incineration capacity in Europe would increase from 71 million tonnes/year in 2008 to 97 million tones/year in 2016 (an increase of 37 %). [Pruvost, 2011] showed a similar increase of (approximately) 65 million tonnes/year in 2006 to 100 million tonnes/year in 2020 (and even 125 million tonnes in an ambitious scenario). This equals an increase of 54 %.

The capacity increase in the EU will still grow after 2016 (and 2020). Current extrapolation will be based for most part on already planned and consented initiatives. Member States lacking behind will still have to invest after that time. A steady increase of 20% even after 2020 could therefore still be feasible.

A2.3.3 Export

The export of plastics out of the EU has increased by a factor of 5 to 6 since the turn of the century [EEA]. Though the largest amount of exported plastics is non-PVC material the amount of exported PVC has most likely increased considerably over time. This increase is the result of two factors. In Europe the landfilling of combustible waste is being reduced as a result of the waste framework directive. Therefore more and more material with a lower quality comes available. Recycling companies in developing countries usually accept lower quality PVC waste than their European counterparts. This is due to acceptance of B-quality goods by consumers, but also due to lower labour costs which make sorting of low quality waste cost effective. At the same time the demand for raw materials has increased in developing countries as wealth is increasing in these countries. These two trends have stimulated export. However the higher quality PVC waste tends to stay in Europe, so export seems to be a balancing factor in the amount of separated waste and the demand in Europe.

A2.3.4 Landfilling

For landfilling the major trend is a reduction. As landfilling is a waste of usable land and of valuable material European legislation is aimed at diverting waste from landfilling to other waste management options. This is captured in legislation in the Waste Framework Directive (and the Directive on the Landfill of Waste (99/31/EC). Between 1995 and 2007 landfilling of municipal waste has decreased for the EU27 from 62 % to just 42 % [EEA Report No 7/2009]. As all the driving factors were still present after 2007 it can be assumed that this decrease has continued. Municipal waste is not directly comparable to PVC waste, though it can be assumed that landfilling of PVC waste follows the same decreasing trend.

A2.4 Distribution over the waste management options

In the modelling the distribution over the waste management options plays an important role. Therefore a most likely scenario for the distribution over the waste management options was developed. Paragraph A2.4.1 describes this scenario. Because the distribution over the waste management options might have a significant impact on the results another scenario was developed based on the seventh European Environmental Action Plan (EAP7). Paragraph A2.4.2 describes this scenario. Both scenarios have been used to calculate the impacts of the different policy options.

A2.4.1 Most likely scenario

Based on the information given in paragraphs A2.2 and A2.3 the impacts of PVC waste management have been modelled starting from the estimated situation in 2010. The 2010 situation is estimated based on the following.

In 2007, estimations yielded 300 ktonnes recycled, 625 ktonnes incinerated and 1,025 ktonnes landfilled PVC waste [Personal communication]. Though only around 250 ktonnes of recycled PVC was recorded by Vinyl2010 in 2010 [Vinyl2010_progress report].
Plastics Europe gives figures for 2010 which indicate that a total around 24.7 Mtonnes of plastics was generated in Europe. Of these 24.7 Mtonnes 10.4 Mtonnes was landfilled, 8.3 Mtonnes was incinerated with energy recovery and 6 Mtonnes was recycled [Plastics Europe 2011]. Although this figure is for all plastics, not PVC only, an indicating ratio can be derived. So the ratio landfill to incineration to recycling should be in the range of 10:8:6. The ratio for PVC is assumed to be slightly different. Plastics Europe states that energy recovery from plastics increased because of usage in cement kilns and power plants. PVC is unsuitable for this purpose because of its chlorine content. In the Plastics Europe figures no information is given about export of plastic waste out of Europe. Because of the longevity of PVC products they aren't regularly collected as is the case with packaging plastics for example. Therefore the recycling rates are expected to be a bit lower than for plastics in general.

Based on the preceding information we estimate the ratio between the waste management options as given in table A2.1.

Table A2.1 Estimated ratio between the waste management options in 2010

Disposal option	Usage ratio (%)
Recycling	10
Incineration	30
Landfilling	50
Export	10
Total available post consumer waste	**100**

The percentages in table A2.1 and in the assumptions below are calculated with the total available post consumer waste as 100 %. With the values given in table A2.1 as a starting point the modelling is based on the following assumptions for post consumer PVC waste

- Recycling increases linearly from 250 ktonnes (approximately 10 %) in 2010 to 500 ktonnes (approximately 20 %) in 2020 [Voluntary commitment]
- After 2020 the increase in recycling is 1%point per year
- 1.5 %point increase of incineration per year in the period 2010 – 2020
  - 1%point increase of incineration per year in the period 2020 - 2030
  - 1%point decrease of incineration per years after 2030
  - Landfilling decreases by 3%point per year until landfilling reaches 0 %
  - Export balances the total of the waste management options

Figure A2.2 gives a graphical representation of the prognosis for the ratios between the waste management options set against time.

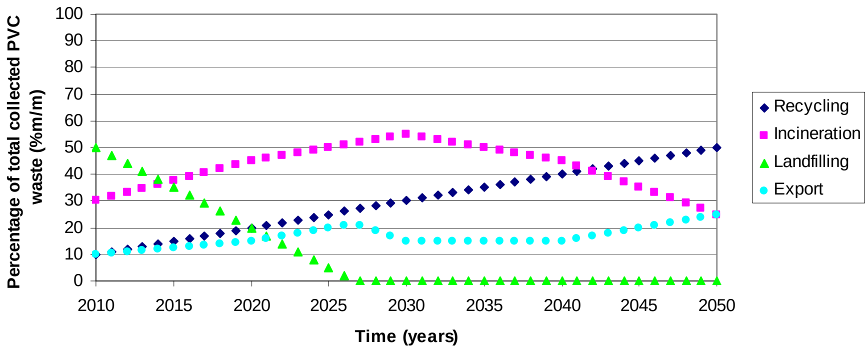


Figure A2.2 Prognosis for the distribution between waste management options in the most likely scenario

If a restriction on the use of lead in articles would be effectuated, this would result in a collapse of post consumer PVC waste recycling in Europe for profiles, pipes and fittings and presumably cable waste. See paragraphs A2.5 to A2.7 for an explanation why this would happen. PVC waste of flooring and roofing contains on average only a very small amount of lead and is used in very low amounts in new articles. Therefore we assume that recycling for these applications would not be blocked by a restriction on lead in PVC articles. Post consumer PVC waste at a reasonable quality would still be a valuable material outside Europe. As there is no legislation which prohibits the export of PVC waste out of Europe at this moment, it is likely that export would increase sharply. The collapse of domestic recycling and increase of export results in a different prognosis for the ratio between the waste management options. The prognosis is given in figure A2.3.

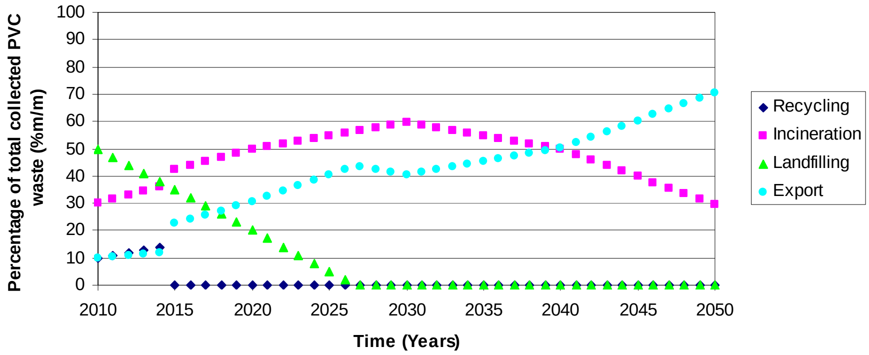


Figure A2.3 Prognosis for the distribution between waste management options in the total lead ban scenario

Figure A2.3 shows that recycling increases until a restriction on the use of lead in PVC is activated. In this scenario we assume the restriction would be imposed starting in 2015. At this point two thirds of the material recycled up until that moment would be exported. One third would go to incineration.

After 2015 incineration would increase and later decrease at the same rate as in the most likely scenario (figure A2.2). After 2030 PVC would start to be diverted from incinerators and be exported. In this scenario we assume that the market in the rest of the world would be big enough to absorb the PVC from Europe and that no legislation would be implemented in the countries of import that would ban the use of lead.

A2.4.2 EAP7 scenario

The prognosis in figure A2.2 gives the scenario that is assumed to be most likely based on the trends given in paragraph A2.3. In order to be able to estimate the effects of a more ambitious goal would be pursued a scenario was developed based on the 7th Environmental Action Programme (EAP7). In the EAP7 two goals are set which have an impact on waste disposal:

- Landfilling will have decreased to zero in 2020
- Incineration with energy recovery is limited to non-recyclable materials only as from 2020

When these ambitious goals will be reached this would mean a distribution between the waste management options as given in figure A2.4.

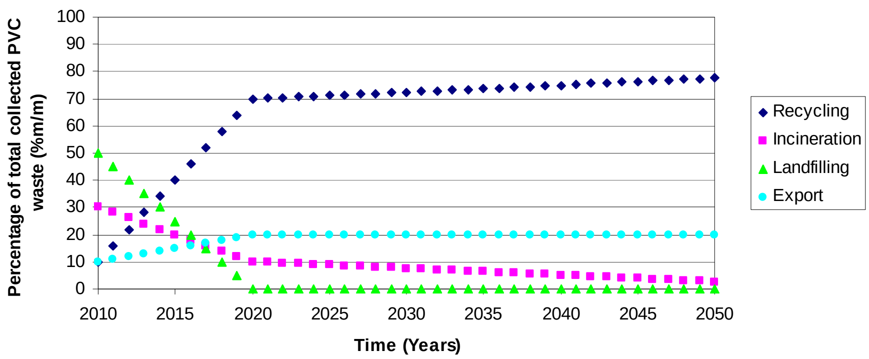


Figure A2.4 Prognosis for the distribution between waste management options in the 7th EAP scenario

Figure A2.4 shows an initial rapid decrease, because of the 2020 targets for incineration and landfilling. After 2020 incineration will continue to decrease slowly as more and more PVC waste will be recyclable because of technical advancement. No detailed investigation was made about the types of PVC waste which are difficult to recycle and which are not. Therefore the assumptions depicted in figure A2.3 are used for all applications.

The two scenarios represented in figures A2.2, A2.3 and A2.4 will be used in further calculations.

A2.5 Is it possible to take lead out of the PVC waste?

If restrictive legislation on the use of lead in PVC is set in place it would constrict the use of PVC waste. The PVC waste which contains lead would not be recycled anymore. The best option seen from an environmental point of view would be to take the lead out of the PVC waste and recycle the rest of the PVC waste and the separated lead. This paragraph describes why this is an unlikely scenario.

A2.5.1 PVC and additives

When we talk about products made of PVC, we are almost always talking about products made of PVC compounds. A compound is made up of PVC polymer, usually called PVC resin, and additives. As PVC resin by itself doesn't have the right properties for most applications additives are used to obtain the right properties for a specific application. The additives are mixed into the PVC resin where the additives are bound by the PVC polymer chains, some more tightly than others. The additives are mixed with the polymer on a molecular scale or on a scale where small islands of additive molecules are mixed in the polymer matrix.

A2.5.2 Three ways of recycling

Recycling of PVC can be done in three different ways.

- Mechanical recycling, where PVC waste is re-used as it is.
- Dissolution recycling, where the PVC is dissolved.
- Feedstock recycling where the PVC waste is broken down to chemical components.

Mechanical recycling

When PVC waste is mechanically recycled, the contaminants in the waste are removed mechanically and the purified PVC waste is ground. The product of this process can be in different forms. In some cases a powder is formed, called micronisate, in other cases flakes of PVC result. When a higher purity is needed the purified PVC-waste is melted and filtered (melt filtration) to remove small impurities before the material is extruded and formed into pellets. The resulting material is a PVC compound which contains the original PVC resin and the original additives. The resulting material is mostly recycled in the original application, although recycling in products that need a similar compound also occurs. Mechanical recycling is the usual recycling method for most types of PVC waste as it is relatively simple and therefore the cheapest option.

Dissolution recycling

When PVC is recycled by dissolution recycling, the PVC waste is dissolved in an appropriate solvent. The resulting solution consisting of solvent with PVC resin and additives can be filtered to remove the solid contaminants, e.g. other polymers that were present in the PVC waste. The resulting solution is condensed to a PVC compound again by evaporating the solvent. The resulting PVC compound consists of the original PVC polymer and the original additives and can be used again in the original application. As the contaminants are removed to a very high degree the resulting compound is almost as good as a virgin PVC compound. The dissolution recycling process is usually applied to flexible PVC where the PVC is mixed with other materials, for example in the case of cable scrap. The PVC waste cable consists not only of PVC, but contains also other polymers and some residual copper and alumina from the cables. Another example is the recycling of PVC tarpaulins with PET fibres. In order for the process to work it is important that the contaminants are insoluble in the used solvent.

Feedstock or chemical recycling

When PVC is recycled into feedstock, the PVC waste is broken down. This can be done by heating the waste until the material falls apart. This way the atoms in the PVC are liberated to form other molecules than PVC resin or additive molecules. The PVC polymer and the additives are destroyed during this process. Depending on the process the atoms of the destroyed molecules are recombined to form feedstock chemicals such as hydrochloric acid, synthesis gas, tar-oil, other oils and sometimes waste in the form of a char or tar which contains the different contaminants.

Feedstock recycling is not so much a recycling option for PVC as a polymer (and additives) but a kind of refinery where base chemicals are formed.

A2.5.3 Removing the lead from PVC waste

In paragraph A2.5.2 the three different recycling technologies were explained. Only the feedstock recycling option would separate lead; recycling by dissolution might conceptually be developed to separate lead but such development is unlikely as explained below. If a ban on lead were to be set in place, conventional mechanical recycling of lead containing PVC waste would be impossible because lead based stabilizer is mixed into the polymer matrix on a (semi) molecular scale.

In the dissolution recycling process, the PVC resin and the additives are dissolved in a solvent. This would be the best place in the recycling process to remove the lead based stabilizer. Removing the stabilizer at this point would probably involve adding chemicals that will bind to the lead stabilizer in order to make the lead precipitate. This extra process step is not developed up to date. It is unlikely that a process to remove lead from PVC waste will be developed commercially in the foreseeable future as the dissolution recycling process is in itself a very expensive recycling method. Adding extra process steps would only result in a more expensive process. The one process plant that applies the dissolution recycling process in Europe recovers around five to six ktonnes of PVC waste per year. This is around 2% of the total amount of recycled PVC in Europe. The low share is a direct result of the high costs of the process. The high costs are partially compensated by higher revenues because the recycled PVC from the Vinyloop process comes close to virgin quality.

Using the different feedstock recycling processes most of the chlorine and carbon content of the PVC compound can be recovered. The lead will remain in a slag, tar or char phase or will have to be removed from flue gas. As the lead will be more susceptible to leaching in these phases it will have an impact on the environment. Recovery of lead as a metal will be difficult and costly, and therefore unlikely. The estimated gate fees for feedstock recycling processes range from EUR 90 for plastic waste containing up to 10 % PVC to EUR 500 for a process where 100% PVC is allowed. The mean value probably lies around EUR 150 – 250 [TNO].

A2.5.4 Conclusion

If the use of lead in PVC articles would be restricted it is highly unlikely that lead would be removed from the PVC waste during recycling because of two reasons:

- At this moment no technical solution exists to remove lead from PVC waste.
- A technology that would remove lead from PVC waste would add costs to the PVC recycling options that are already (too) expensive. It is unlikely that this will happen.

A2.6 Is it possible to (keep) separate lead free and lead containing PVC wastes

If a restriction on lead in new PVC products is effectuated, the recycling of lead containing PVC waste in Europe would be stopped as it would be illegal to use the recycled material. However PVC waste would still be arising, both lead containing and lead free waste. Lead free PVC waste would still be recyclable as long as it is clear that the lead content of the new product is below the restriction threshold. In order to be able to recycle lead free PVC waste a clear distinction would have to be made between lead containing and lead free PVC waste.

The distinction is especially difficult for post consumer waste as this is a very heterogenic mixture. Post consumer PVC waste rarely arises as a separate stream. Usually it is contained in municipal waste or construction and demolition waste. This means that effort is needed to (keep) separate the PVC waste from other wastes. Post consumer PVC waste would remain in the different waste streams because taking the PVC waste out of these streams would be costly and possibly useless as the material would not be allowed to be recycled into new articles as it might contain lead.

The total mixture of post consumer PVC would still contain an amount of lead free PVC as lead was not used in all the different PVC products. In order to obtain this lead free part of the post consumer waste one would have to separate the whole post consumer PVC waste from other waste streams and following this step the lead containing material would have to be somehow separated from the lead free material.

In this paragraph we describe the options to (keep) separate the lead containing material from lead free material. However separating lead free and lead containing PVC waste is not the end of it. After separation, the lead free material can be recycled in Europe but the lead containing material has to be exported or disposed of in an incinerator. In the latter case the costs for the disposal of PVC waste containing lead would be very high. That is because of the high calorific value, the formation of hydrochloric acid in the incinerator resulting in possible damage and the formation of air pollution control residues. If lead containing PVC material can be exported, a sorting process distinguishing between lead containing and lead free might be economically feasible. In the long run this might become more difficult as non-EU countries are likely to introduce restrictions on heavy metal comparable to EU legislation.

In the following subparagraphs we discuss different methods to (keep) separate lead containing and lead free PVC waste.

A2.6.1 Keeping wastes separate based on the origin

If a restriction on the use of lead in articles is in place, the production of PVC products from virgin material can be assumed to be lead free. Therefore production wastes and installation wastes of these new products can be defined as lead free. Post consumer waste consists of lead containing and lead free waste, therefore it can never be considered with certainty to be lead free. Based on this distinction, only production waste and installation waste can be recycled with the certainty that it would not result in introducing lead in a new product.

This makes a relatively cheap and effective separation possible based on the origin of the waste. This system is robust as the convertors would be the parties to guaranty the recycler that the PVC waste is lead free, while at the same time the convertors would receive the recycled material in the end. Therefore the responsibility to provide lead free PVC waste lies with the party that has most to lose. A system where production and installation wastes are kept separate from post consumer waste already exists in a general sense. The price for recycled PVC production waste is higher than for post consumer PVC waste, therefore we can assume that the distinction is made in practical cases. A refinement of this system in the case a total ban on lead in articles would be put in place is highly likely. This system however would not solve the essential issue of the arising post consumer waste.

A2.6.2 Separating wastes based on sorting

When lead containing PVC waste and lead free PVC waste is collected commingled the whole lot should be classified as lead containing thus lowering the value of the material. Even though the whole lot is lead containing, it is possible that recyclable lead free material is present in the lot. In order to separate the lead containing material from the lead free material two approaches could be followed:

1. Marking all the lead free produced material and hand sorting

When a producer changes the stabilizer system to a lead free system, this can be marked on the product. Cables, piping, flooring and roofing usually are already marked. A marking is not so much of an extra effort in that case. For (window) profiles this might be more of a problem, as these are not generally marked. As articles in the waste stage are often broken it is possible that the marking will not be present on all particles to be sorted, thus resulting in keeping part of lead free PVC waste in the lead containing fraction. A good marking would make hand sorting possible to a certain extent, though it would probably be costly. Besides, as articles have not been marked in the past these legacy articles would be lost for recycling when sorting by hand. Hand sorting is deemed unlikely because of the high cost and the inevitable loss of lead free material because it cannot be identified. Besides, due to the long life time of most PVC products, such a system would only start to be effective after several decades.

2. Separating the material based on scanning technologies

It is possible to measure lead content in PVC material based on XRF technology [USCPSC, VITO]. A sorting apparatus probably can be constructed based on scanning technology and standard air pulse technology. An apparatus as such does not exist at this moment and developing it would have to overcome several issues, such as the reliability, the radiation hygiene, and the practical detection where the detector almost has to touch the sample to work properly. Besides, a lead containing inner layer could be (partially) shielded by a lead free outer layer. The quality of a sorting apparatus would have to be relatively high as only 5 % of material with a 2 % lead content in a lead free lot would increase the total lead content of a lot to around 0.1%. These difficulties would have to be tackled before a commercially available sorting machine would be available.

Sorting machines are rapidly becoming cheaper, making mechanical sorting based on lead content possible. Sorting machines usually can be applied only if the throughput is high enough. This is because the investment costs are relatively high. In theory automatic sorting might become possible in the future. However, because lead was used so widely until recently, the proportion of lead free post consumer waste will remain relatively low for many years, which undermines the economic justification of such an investment

A2.6.3 Conclusion

We conclude that if a lead restriction would be effectuated,

- Lead free PVC production waste would be kept separate and would be recycled;
- Post consumer PVC waste would not be recycled as it might contain lead;
- Separation of post consumer waste in lead containing and lead free will be unlikely as separation by hand is impossible and mechanical separation does not exist at the moment. Besides, the lead containing part of the PVC waste would have to be disposed of at a premium for incinerating a 100 % PVC waste stream is costly

A2.7 Stockpiling PVC waste until a better recovery option is available

Based on the idea that separation of lead free and lead containing PVC wastes might be possible in the future, and even the removal of lead from PVC waste prior to recycling might in theory eventually be possible, one could suggest to keep the PVC waste in order to recycle the material in the future.

However this would mean making huge costs now in order to maybe recycle later. The biggest part of the present costs would be made for the separation of the PVC waste from other waste streams. The storage itself would be another costly undertaking. Besides the space needed to stockpile the PVC waste would be huge. According to the EuPC model the PVC waste arising in 2010 would be 2.49 million tonnes. With an assumed density for compacted PVC waste around 300 kg per m^3 the yearly amount of space needed to stockpile the PVC waste would be 8.3 million m^3. This volume is approximately seven times the volume of Wembley stadium. And when loaded into trucks this volume would need 103,750 trucks with a trailer. If this many trucks and trailers would be parked in a line they would reach a length of approximately 2,000 km.

A2.8 Literature for Appendix 2

[Manders, 2010] Developments on Waste to Energy across Europe. Jan Manders, Presentation at WTERT Columbia, 2010

[Pruvost, 2011]Potential for increased aluminum recovery from bottom ashes in Europe. Francois Pruvost, Presentation at CEWEP Seminar 2011.

[TuTech] Dipl.-Ing. Ivo Mersiowsky TUHH Technologie GmbH (TuTech) CONTRIBUTION OF POST-CONSUMER PVC PRODUCTS TO LEAD INVENTORY IN LANDFILLED WASTE, *Substance Flow Analysis Report Commissioned by: European Council of Vinyl Manufacturers (ECVM) European Stabilisers Producers Association (ESPA)*

[Argus] ARGUS in association with University Rostock-Prof. Spillmann, Carl Bro a|s and Sigma Plan S.A.: The behaviour of PVC in landfill, commissioned by DGXI.E.3, February 2000

[Bertin] Bertin Technologies Tarnos, VKI-Water Quality Institute, Forschungszentrum Karlsruhe: THE INFLUENCE OF PVC ON THE QUANTITY AND HAZARDOUSNESS OF FLUE GAS RESIDUES FROM INCINERATION, contractnumber: B4-3040/98/000101/MAR/E3, April 2000

[TNO_incineration] L.P.M. Rijpkema, TNO Institute of Environmental Sciences, Energy Research and Process Innovation: PVC and municipal solid waste combustion: Burden or benefit?, December 1999, order nr: 30316, commissioned by APME

[USCPSC] US Consumer Product Safety Commission: Study on the Effectiveness, Precision, and Reliability of X-ray Fluorescence Spectrometry and Other Alternative Methods for Measuring Lead in Paint, August 2009

[VITO] VITO: Study on the cadmium content of recycled PVC waste, 2009/TEM/R/189, December 2009

[EEA] http://www.eea.europa.eu/data-and-maps/figures/exports-of-waste-plastics-and/exports-of-waste-plastics-and/image_original Accessed at March 21th 2013.

[EEA Report No 7/2009] European Environment Agency: Diverting waste from landfill Effectiveness of waste-management policies in the European Union, ISBN 978-92-9167-998-0, ISSN 1725-9177, DOI 10.2800/10886, June 10, 2009

[Personal communication] Communication with a representative of VinylPlus

[Plastic Europe 2011] Plastic Europe: Plastics - the Facts 2011, An analysis of European plastics production, demand and recovery for 2010.

[Vinyl2010_progress report] Vinyl 2010: 2011 Progress Report, reporting on the activities of 2010 and summarizing the key milestones of the past 10 years, Accessible at: http://www.vinyl2010.org/images/progress_report/2011/vinyl2010_progress_report_2011_final.pdf

Appendix 3

Modelling post consumer PVC waste and lead concentrations

A3.1 Introduction

In order to estimate the impacts of different policy options we have identified indicators in paragraph 5.2. The indicators for example are how much CO_2 would be emitted compared to the business as usual scenario. The indicators can be calculated based on the amount of available post consumer PVC waste and the lead content in that PVC waste. The production waste is disregarded because we assume that production waste would comply with regulations and therefore can be recycled in all the policy options.

This appendix describes how the mass of yearly available post consumer waste is calculated and what the lead content would be for the different applications. The amount of PVC waste per product type is estimated using a model developed for EuPC. The available waste data was made available by EuPC to the researchers. A description of this model can be found in paragraph A3.2.

The lead content in the available waste is calculated based on the lead content for the different applications in the past. Paragraph A3.3 describes the general lead concentration profile for all PVC products. Paragraph A3.4 describes the lead content for the different product groups. In paragraph A3.5 an overview can be found. In paragraph A3.6 the consulted literature is given.

A3.2 Description of the EuPC Dynamic Waste Analysis model

EuPC has developed a computer model which estimates the mass of post consumer PVC waste that is arising for all the applications in Europe. This Dynamic Waste Analysis model is hereafter referred to as the DWA model. The input for the DWA model is historic production data based on the production of virgin materials (PVC resin and additives), product intermediates (compound) and finished products. Besides these production figures information about import and export is used based on national statistics on export and import of PVC articles. Based on this input information the model calculates the mass of all the different PVC applications which are put on the market per year in Western Europe (EU15). An estimation of the future production per application is based on the growth rate of the last six years for that specific application. Figures including the year 2011 have been used.

The model combines the average lifetime of the different applications with the yearly production figures to calculate the mass of PVC waste which would potentially arise in a given year. Part of the potential waste will never become available as the material, for example piping, will remain buried in the ground. Based on expert judgment a correcting factor is applied to the mass of potential waste to obtain the available post consumer waste.

The model thus outputs the available post consumer PVC waste per year for all the different applications. In order to calculate the lead content in this waste information about the lead content in the past is necessary. This is discussed in the following paragraphs.

A3.3 How much lead is present in PVC products?

A3.3.1 Introduction

In annex 1 the two uses of lead were described. Generally speaking the concentration of lead as a result of added lead pigments is about ten times lower than the concentration of lead added as stabilizer [Teppfa, personal communication]. Besides only a small amount of PVC products have been coloured with lead containing pigments. As the estimation of the amount of lead stabilizer is not very precise because of lacking data from the past we do not try to estimate the amount of lead based pigment as this would be smaller than the error margin in the estimate for the lead used as stabilizer. Therefore we only estimate the amount of lead used as stabilizer and we disregard the amount of lead used as pigments.

In this report when an amount of lead is given we mean the amount of lead in metallic form. We use the unit %m/m for the lead concentration. This means the mass of the metallic lead divided by the mass of the PVC compound expressed in a percentage. If an amount of lead is given as lead stabilizer it is explicitly mentioned in the text.

As different products have different uses, the material used to produce the product needs to have different properties. The different products mentioned in paragraph 3 of this annex therefore have different concentrations of lead. For example most piping is used below ground or in the walls of buildings. Therefore piping receives little UV light. Most PVC piping therefore does not contain a stabilizing agent in order to stabilize against degradation caused by UV light.

It should be noted that most producers of PVC products use their own compound and therefore might have a different lead concentration in its products. These differences might be the result from differences in knowledge of the producer, differences in markets and differences in the other components used. The concentrations given below must be read as an average lead concentration for a given product type, bearing in mind that higher and lower lead concentrations will exist. As we are discussing large waste volumes, and post consumer waste usually is a mixture derived from products of different producers, the average lead concentration gives a fair description of reality.

A3.3.2 Lead concentrations over time

The amount of lead in the different products has changed with time. For most product types the concentration has changed as given below in figure 8.1 (blue line, left axis). The same figure also gives the amount produced of the lead containing product (pink line, right axis).

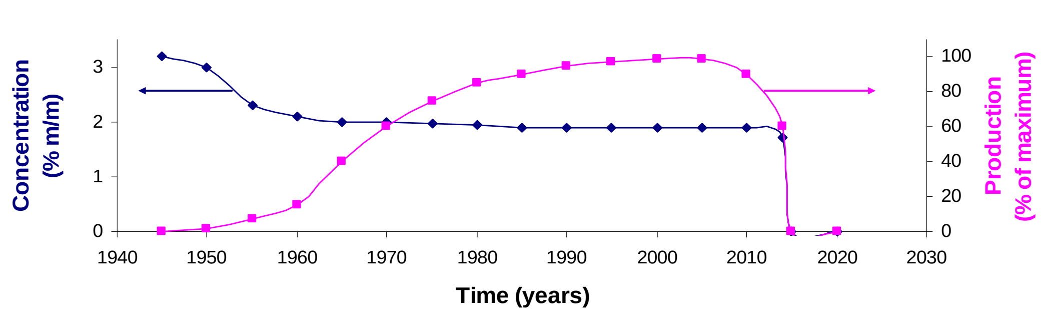


Figure A3.1 Model of change of lead content and production in time for a product made of virgin material

Figure 1 shows the average concentration of lead in a model product type such as window profiles or piping. Note that the figure is just a model and doesn't give the concentration for a real product. Initially the concentration of lead was high for a few years. In this time PVC was just starting to become used in this type of product. As knowledge of PVC was still developing and properties of different compounds were not as well known as today a bit more stabilizer was used than is technically necessary. When knowledge developed and more became known about PVC and the additives in the compound producers found out that less stabilizer was needed and consequently the concentrations went down quite rapidly. In the following years the concentration of lead slowly declines as knowledge and experience with PVC and lead stabilizers increases still further. After the rapid decline in the earlier years the decline is now quite slow as the stabilizer concentration reaches physical limits. Around the year 2000 the call for phase out of lead becomes stronger and producers start looking for alternative stabilizer systems. Starting around the year 2005 these alternatives have been developed enough to make the switch from lead to other stabilizers such as Ca/Zn stabilizers. The concentration of lead stabilizer has remained almost unchanged for the last 30 to 40 years. The year 2015 is a relatively strict date for the concentration to be zero as the PVC industry has made a voluntary commitment to phase out lead stabilizer before 2015.
Not all the product types have used lead stabilizers from the beginning. Some products have used cadmium stabilizers and have changed to lead somewhere along the way. A graph for these products will generally have the same form as the graph in figure A4.1 because the production of lead containing products has started later in time, the lines will also start later. The production amount will probably increase more rapidly in this situation.

Figure A3.1 shows that the amount of product made with a high concentration of lead is relatively low. In the example the bulk of the production was made with a lead concentration around 2%. This amount is several orders of magnitude higher than the amount made with a higher concentration in the earlier years. PVC waste resulting from the production of a given year is available over a multitude of years up to a few decades later. This means that PVC waste from the production in a particular year is mixed in with the PVC waste from many other production years. The smaller amount of PVC waste from earlier years, with a higher concentration of lead, will be mixed with larger amounts of PVC waste of later years, with a lower concentration of lead. This results in an average lead concentration comparable to the lead concentrations in recent years.

For this reason the lead concentrations in post consumer PVC waste arising at this moment are assumed to be comparable with lead concentrations at the plateau.

A3.4 How much lead is present in the different applications?

In paragraph A1.2 we have identified the PVC applications which have contained lead in the past. In this paragraph we estimate the lead content in products from the past and the market share of lead containing products for each of these five applications.

A3.4.1 How much lead is present in profiles?

Profiles usually receive a high dosage of UV light. Therefore the amount of lead in profiles is relatively high compared to other products. The amount of lead in profiles is estimated according to different sources as follows:

Table A3.1 Lead concentration in profiles

Source		Concentration (%m/m)
Veka, personal communication [citation needed]	Window profiles	1.9 – 2.0
[TuTech] (based on personal communication)	Window profiles	2.0
[TuTech] (based on personal communication)	Profiles for other building applications	1.8
[TuTech] (based on personal communication)	Profiles for cable ducts	1.6
[TuTech] (based on personal communication)	Profiles for furniture	2.0
[TuTech] (based on personal communication)	Profiles miscellaneous	1.0
[Randa]	Window profiles	2.0

The estimated lead concentration in profiles in the different sources ranges from 1.0 to 2.0%m/m. Based on the above percentages we might assume an average lead concentration of approximately 1.8%m/m. However, in practice there is a difference in collection of post consumer profile waste. Window profiles are collected to a higher percentage than other profiles because a collection scheme is in place for window profiles and roller shutters (Rewindo) whereas there is no collection scheme for other profiles. Window profiles have a lead content of 2.0% whereas the other profiles have a lower lead content. The lead content of the collected post consumer waste will be higher than the arithmetical average of the values given in table A3.1. As the majority of the recycled profiles that will return in the profiles will have a lead content around 2.0%m/m. We use this value for all the profiles in our calculations.

The market share of lead containing products within this application is estimated by experts from EPPA as given in table A3.2.

Table A3.2 Market share of lead stabilizer in profiles per year

1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
0	2	4	6	8	10	12	14	16	18	20	22	24	26

1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
28	30	42	53	65	77	88	100	100	100	100	100	89.2	89.1

2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
93.5	83.3	79.8	78.7	66.2	47.7	31.7	24.1	18.2	12	7	3	1	0

In the past cadmium was used to stabilize PVC profiles. Lead was used starting in the mid 70's. Around the turn of the century lead started to be phased out. The voluntary commitment of VinylPlus will assure that no new lead will be used after 2015.

A3.4.2 How much lead is present in pipes and fittings?

Pipes and fittings are usually buried in the ground or covered in buildings. They therefore have a low exposure to UV light. This would indicate a low lead concentration. However pipes and fittings generally have a very long life span the amount of lead cannot be too low as this would result in product failure near the end of the lifespan of the product.

Table A3.3 Lead concentration in pipes and fittings

Source	Material description	Concentration (%m/m)
[Randa]	Pipes	0.75
[Teppfa] (personal communication)	Producer A: Fittings (injection moulding)	2.0 – 2.5
	Producer A: Pressure piping	0.6
	Producer A: Pressure less piping	0.5
	Producer B: Injection moulded parts	2.3
	Producer B: Pressure less piping	0.68
[NPG]	Pipes (years 1965 – 1949)	2.0 – 0.75
[OKI]	Drinking water pipes in Austria	In practice <1%

Table 2 shows that pipes and fittings have a relative broad range of lead concentrations. This is the result of the difference in production process. Piping is made by extrusion. Fittings are injection moulded. In the latter case the residence time is longer and therefore the PVC is at a higher temperature for a longer time. Therefore injection moulded products have to be stabilized more. There is a slight difference in the lead concentrations of pressure piping and pressure less piping. As pressure piping needs to have a higher mechanical stability this kind of piping is usually stabilized a bit more in order to guarantee the structural integrity of the pipe. The difference however between the two types of piping is smaller than the difference between two different producers. It is estimated that about 9 % of the total production of pipes and fittings consists of fittings (injection moulded) the rest is pressure and pressure less piping.

Based on the data given in table 2 we assume that fittings have a lead content of 2.3 % and piping has a lead concentration of 0.6 %. Combined with the percentages received from Teppfa this results in an average lead concentration of 0.75%m/m. This compares to the overall lead concentration as given in [Randa].

The market share of lead stabilizer in pipes and fittings is estimated by experts from Teppfa. The results of this estimation is given in table A3.4

Table A3.4: Market share of lead stabilizer in pipes and fittings

Before 2000	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
100	100	89.2	89.1	93.5	83.3	79.8	78.7	66.2	47.7	31.7	24.1	18.2	12

2013	2014	2015	2016
7	3	1	0

Lead has always been the preferred stabilizer in piping. Around the turn of the century lead stabilizer started to be phased out in favour of calcium zinc stabilizers. The voluntary commitment of VinylPlus will assure that no new lead will be used after 2015.

A3.4.3 How much lead is present in flooring?

Phasing out of lead in flooring was finished already about five years ago. The last 15 years lead has been used only incidentally in flooring [ERFMI]. As flooring trends changes quite fast the flooring products change quite fast too. Therefore it is difficult to estimate an average lead content in PVC flooring products. Not all flooring products made of PVC have contained lead stabilizers. Generally speaking three categories of PVC flooring exist. They are given, in order of tonnage, below combined with the stabilizer system used in the production [personal communication with ESPA].

1. Cushion vinyl: made from plastisols and always liquid stabilizers are used. In the past, could have contained cadmium, never lead
2. Calendering: always liquid, barium-zinc or calcium zinc today, in the past could have contained cadmium
3. Compact (pressed) floor tiles: some liquid stabilizers but also solid stabilizers: today solid calcium zinc, in the past a few producers were using lead

The last category has contained lead stabilizers in the past. Due to staining issue in contact with sulphur (contained in the rubber cushion layer) lead has never been very popular. After the years '80 the use of lead stabilizers was likely restricted to some niche applications. If lead was used, it would have been at max 0.8 % as Lead and totally disappeared before 2000. This information is comparable to the information in [TuTech] where it states: "*The use of lead stabilizers in flooring products is restricted to solid calendered flooring tiles, rather than the predominant flooring formulations for spread coating (vinyl cushion flooring).*"

The figures for the lead concentration in flooring applications are given below in table A3.5.

Table A3.5 Lead concentration in flooring

Source	Description	Concentration (%m/m)
[Healthy Stuff]	Recent vinyl tile flooring in the USA	0.19 max
[ESPA]	Compact (pressed) floor tiles	0.8 max

As the ESPA information relates to the European situation, the lead concentration of 0.8%m/m is chosen as the value with which the further calculations are executed. Only compact flooring was taken into account in the calculations.
The market share of lead stabilizer in the compact flooring is very difficult to estimate. Limited information is available as flooring products change rapidly in order not to be outmoded. The best estimate for the market share is given in table A3.6.

Table A3.6 Market share of lead stabilizer in calendered PVC flooring

1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
55.5	54	52.5	51	49.5	48	46.5	45	43.5	42	40.5	39	37.5	36

1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001 and further
34.5	33	30.5	30	28.5	27	25.5	21	15	9	6	3	0

The market share of lead stabilizers in compact flooring was never very high as lead is known to cause staining. The best estimate assumes a steady decline starting in the mid ‘70s. The voluntary commitment of VinylPlus will assure that no new lead will be used after 2015.

A3.4.4 How much lead is present in roofing?

Information on the lead content in roofing is very limited. The best estimate from ESWA experts is 1.2%m/m lead in the roofing material. As no further information could be found this value has been used in the further calculations.

The market share of lead stabilizer is assumed to be as follows. The information about market share is supplied by ESWA.

Table A3.7 Market share of lead stabilizer in PVC roofing

1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
70	67	63	60	57	53	50	47	43	40	37	33	30	27

1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
23	22	20	18	16	14	12	10	8	6	4	2	<1	0

2012	2013	2014	2015	2016
0	0	0	0	0

The market share of lead stabilizers has declined since the mid ’80s. Since 2010 none of the ESWA members use lead stabilizer, thereby complying with the voluntary commitment of Vinyl Plus to phase out lead stabilizers before the end of 2015.

A3.4.5 How much lead is present in cable jackets/sheaths?

Cables can have a PVC jacket or sheathing. PVC is chosen as PVC is relatively fire retardant. As there are many different cable types with different specifications, the concentration of lead varies across a wide range.

Table A3.8 Lead concentration in cable jackets/sheats.

Source		Concentration (%m/m)
Randa	General concentration for cables	1.6
Baerlocher (personal communication)	In finished jacket	1.6
	High temperature cables	3.5
USA EPA	CMR cable (Tribasic Lead Stearate)	1.8
ESPA (personal communication)	Car cables	2.1 – 4.2
	Domestic cable Insulation	1.0
	Domestic cable Jacketing	0.7
	Electrical appliances	1.55
	Information and power systems	1.0
	Miscellaneous	1.2
Mizunu et al	Basic formulation	1.1 – 1.8
Greener PVC	Control sample	~2.15

The relative amount of the different types of cables is not well known, but is estimated as 15 % automotive (high temperature), 20 % electrical appliances and 65 % low voltage cables in buildings [ECVM]. This leads to a general lead content around 1.5 %. The concentration of 1.6 % given by [Randa] is an estimate for all cable material. This concentration is comparable to the general lead content of 1.5 % and lies in between the other concentration in table 5. As no further information is available and this value is used in a life cycle assessment report commissioned by the European Commission <u>we use the same value, 1.6 % lead in PVC in cables, for this report.</u>

The market share of lead stabilizer in cables is assumed to be as given in table A3.9

Table A3.9 Market share of lead stabilizer in cables

1999 and earlier	2000	2001	2002	2003	2004	2005	2006	2007 and further
100	100	85	70	55	40	25	5	0

The market share of lead stabilizer has traditionally been around 100 %. Around the turn of the century a quick change to other stabilizer systems has started under pressure of European legislation in the form of RoHS/WEEE and ELV directives. Since 2007 the market share of lead stabilizers in cables is around 0 %.

A3.5 Overview of the lead concentrations for the applications

In the preceding paragraph the lead content and the market share of lead stabilizer was derived per application. In this paragraph we give an overview of the derived values combined with information on the recycling of the waste per application. These values can be found in table A3.10. The lead concentration given is the concentration which is used for further calculations. The starting year of lead use and year of phase out give an impression of the market share of lead stabilizer in comparison to other stabilizer systems. The phase out pace gives a description of the time taken to phase out the lead containing stabilizers. The ending year is the latest year in which a significant amount of lead based stabilizer is used for that application.

Table A3.10 Overview of lead usage in the different applications

	Profiles	Pipes	Flooring	Roofing	Cables
Lead concentration (%m/m)	2	0,75	0,8*	1,2	1,6
Starting year of lead use	1975**	Since start	Since start	1985	Since start
Starting year of phase out	2000	2000	2000	2000	2000
Phase out pace	Normal	Normal	Early	Normal	RoHS
Ending year for newly added lead	2015	2015	2000***	2015	2007
Max. % of recyclate	70%	65 - 100%	10%	12.5%	0%
Average % of recyclate (when used)	40%	65 - 100%	?	12.5%	0%
% used in own application	81%	100%	70%	<1%	0%
% used in other applications	19%	0%	30%	>99%	100%
Used in other application:	Pipes	-	Road cones, tubing	Non-domestic floor covering, 5% in other membrane	(Roofing) sheets, road cones, animal floor covering

* The value mentioned is only in *compact flooring*. Other PVC flooring types have shorter lifetimes and have never contained lead.

** slow increase up to 1990, fast increase from 1990 – 1996, 100% Pb usage 1996 - 2000

*** One small application with lead was identified between 2000 and 2005. The lead amount in the total is negligible.

The maximum percentage of recyclate gives the maximum amount of recyclate that can be used in a single product. For example depending on the usage a pipe can be made of 65 % of recyclate and 35 % of virgin material. In some instances pipes can be made from pure rPVC. On the other hand in cables no recycled PVC is used as under no circumstance the shielding functionality of the sheathing may be diminished. The maximum percentage of recyclate given in table A3.10 is thus a technical maximum. In practice usually a lower amount of recyclate is used as production at the technical limit is not cost effective. The average percentage of recyclate in table A3.10 reflects this amount. This amount is the percentage of recyclate that is usually applied *if* a product contains recyclate. Most products nowadays are still made from virgin material only. Usage of recyclate will only happen when a minimum amount of recyclate can be used, balancing the revenues of a lower price for the recycled material against the higher cost for processing (lower throughput, higher investment costs, and higher labour costs).

The percentage used in own application reflects the amount that is in a loop and is reused in the same application. For example 81% of the recyclate that originates from profiles is being reused in profiles. Recyclate from cable sheathing is never reused in the production of new cable sheathing. The rest, in the table given as *% used in other applications* is used in the other applications given in the row below this number. In the profiles case, 19% of the recycled PVC derived from profiles was reused in pipes.

A3.6 Literature list for appendix 3

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[Randa] Life Cycle Assessment of PVC and of principal competing materials

[PVC handbook] Charles E. Wilkes, Charles A. Daniels, James W. Summers, ISBN 3-446-22714-8

[ERFMI] Personal e-mail communication with Mr. J. Zimmermann from ERFMI.

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[OKI] Ostreichisches Kunststoff Institut, Lead Migration from PVC drinking water pipes, Pa nr 33.486, July 1995.

[Mizuno et al] Mizuno, K., Hirukawa, H., Kawasaki, O., Noguchi, H., and Suzuki, O., 'Development of non-lead stabilized PVC compounds for insulated wires and cables', Furukawa Review, No. 18, 1999, pp.111–118.

[Greener PVC] The Massachusetts Toxics Use Reduction, Institute University of Massachusetts Lowell: Green(er) PVC: The Development of Lead and Phthalate-Free Nanocomposite Formulations with Practical Utility

Appendix

4

Modelling lead in new PVC products made with recycled material

A4.1 Introduction

In the preceding appendix we explained how the available waste and the lead content in the waste was estimated. In this appendix we explain how, based on these inputs, the lead content in new articles has been estimated.

A4.2 Description of the modelling

This paragraph describes how the lead concentrations in the post consumer PVC waste that arises in different places in society was estimated. In order to estimate the lead concentration in the waste it needs to be clear at which point waste arises. Therefore a graph has been made that roughly describes the movement of PVC through society. This graphical representation is given in figure A4.1.

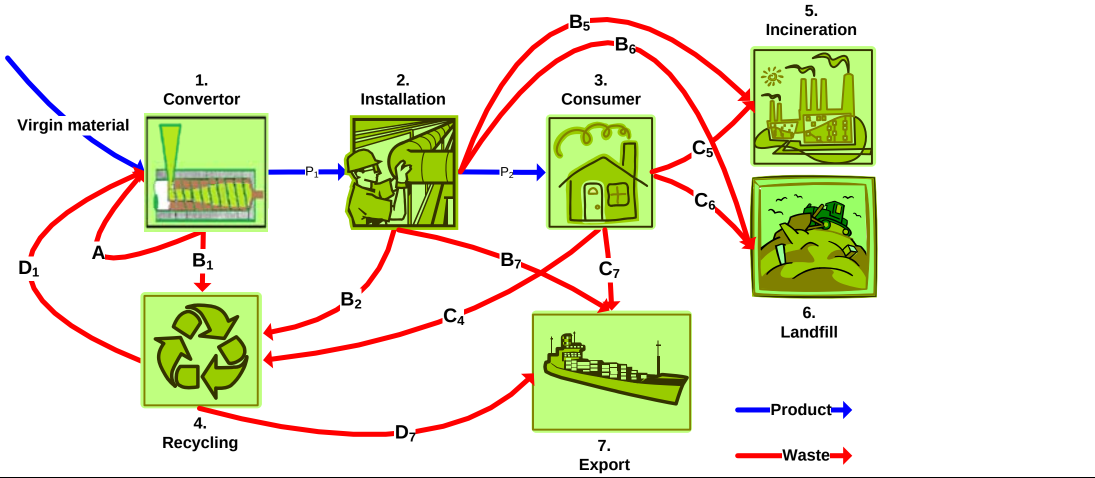

Figure A4.1: Schematic representation of PVC material streams in society

The life of PVC articles starts in the conversion facility of the convertor (1.). During conversion PVC articles, for example pipes, are made of virgin and recycled material. Often the articles are sold and installed by a professional, such as a plumber, during installation (2.). Next the articles are being used by consumers (3.). After a certain period the article is discarded, for example when the consumer wants a new bathroom. If the articles aren't reused, for example as second hand articles the product life of the pipe ends and the waste stage commences.

PVC waste can be recycled (4.), incinerated (5.), landfilled (6.) or exported (7.). After incineration or landfilling, PVC waste is removed from society. If the material is sent to a recycler, the PVC will start a new cycle. In this model a recycler is defined as an organization that makes granulated material ready to be extruded again in the normal production process of a convertor. Another option to reuse the material is export (7.) out of Europe where the material is used again abroad.

Waste not only arises after consumption. In all stages of the article life waste arises. The first place where waste arises is during production. Waste might result of machinery failure, for instance because an extrusion nozzle is partially blocked. The product does not comply with the specifications, but the material in the product is of good quality.

Usually this waste[1] (A) is scrapped onsite and reused in the production facility. Generally speaking this material will never have a lead concentration above legislative levels as the waste material has the same composition as finished products which have to comply. Sometimes in-house recycling is impossible, for example because a rubber was extruded into a PVC profile. In this case the PVC waste (B_1) will be transported to a recycler (4.) where it will be made ready for reuse in the production process. Again the material will generally have a lead content in compliance with legislation as the composition is comparable to the composition of PVC products. The same applies to waste that arises during installation. During installation cut offs might arise. This high quality material is premium feedstock for recyclers as it is almost directly reusable in production. Therefore this material is usually sent to recyclers. However not all waste material is sent to recyclers after installation. PVC waste will also be sent to incinerators, landfills or exporters.

Waste arising after the consumer has used PVC articles (C), also known as post consumer waste, generally is not such a premium feedstock. The material usually is contaminated with all kinds of other materials, and important for this study, it might contain lead in concentrations above the restriction threshold value for some of the policy options. If not sent to a recycler, the waste can be incinerated, landfilled or exported.

When the different waste streams (B, C) arrive at the recycler they are generally mixed and processed together. A mixed stream (D) results which can be used in the production of new products or which is ready for export. In some policy options lead containing material and lead free material could be kept separate in order to supply lead free material to European production.

As post production PVC waste will in general comply with legislation it will most likely always be recycled. Therefore post production waste has not been calculated in the further modelling.

A4.3 Assumptions

In building the calculation model some assumptions have been made. These assumptions can be divided in three types. The first are the general assumptions, which define the model and are used for all the policy options and for all the different product types. The second are the policy specific assumptions which only apply to one of the policy options, for example policy option 5B. The third are the product specific assumptions, which apply only for a specific product, for example cables.

Besides assumptions on the way the model works, input assumptions are made. These input assumptions are numerical values which are used to calculate output values in the same or a later year. These input assumptions are given for each type of assumption.

A4.3.1 General assumptions

The model is based on the following general assumptions:

<u>Modelling assumptions</u>

1. Import and export of PVC articles into the EU are assumed to balance each other and are assumed to be negligible compared to production. Therefore they are not modelled
2. Total production volume (P_1) complies with legislation regarding lead content

[1] Legally this material isn't waste as no-one wants to dispose of it. For the ease of reading the term waste is used.

3. Lead concentration of A, B_1, B_2, B_5, B_6, B_7, P_1 and P_2 are the same
4. Lead concentration in P_1 is the result of the ratio between virgin and recycled material (D_1) and the lead concentration in the recycled material (D_1)
5. The waste arising that can be recycled in-house is recycled in the same year as it arises. Therefore the amount of (A) is set to zero
6. The lead concentration of the material that is recycled in Europe (D_1) is equal to the lead concentration of the exported material (D_7)
7. Post consumer waste is well mixed so the lead concentration of all post consumer waste (C4, C5, C6 and C7) is the same
8. The base year is 2010. Figures in other years are (partially) derived from this year
9. Collectible waste is recycled, incinerated, landfilled or exported in the same year as it arises
10. The total amount of recycled PVC (minus export) is spread over all the convertors. The material is defined as unusable when there is more recycled material available than can be used by the convertors because the lead percentage in the product would be higher than allowed or the technical maximum percentage of recycled material is reached. The co-extrusion capacity is assumed to grow with the amount of secondary material available
11. Removing lead from PVC waste is not taking place. See appendix 2 for the foundation of this assumption

Input assumptions

1. Production waste arising which is recycled outhouse (B_1) as percentage of total production volume is zero. Technically this isn't correct. As no information about outhouse recycling is available this is the best simplification assumption that can be made
2. Post consumer available waste arising per year (Sum of C_4, C_5, C_6 and C_7) This value is derived from the EuPC model Dynamic Waste Analysis (DWA)
3. The proportion of PVC waste going to recycling, incineration, landfill and export is described in appendix 2. The modelling calculations will use two scenarios for the distribution over the disposal options
4. Different assumptions have been made if a lead ban would come into force. See appendix 2 for the reasoning behind this distribution
5. Recyclate will only be used in piping and profiles if a minimum amount of 25% in the finished product can be used. Below this percentage the lower costs of recycled PVC do not outweigh the added costs for using a more complex production process which is needed to use recyclate. The same applies for cable isolation/sheathing waste, although it is used only in non-cable products. For roofing and flooring the minimum amount is set at 10%. A safety margin of 5% is used in order for a convertor to stay safely below a limiting concentration. In the case of flooring a 2% safety margin was used

A4.3.2 Assumptions per policy option

In this paragraph we give the assumptions for the different policy options.

Policy option 1

As this policy option is the base line option, no specific assumptions are used.

Policy option 2

As post consumer recycled material might contain lead, this material is not sent to recyclers but would be incinerated, landfilled or exported. C_4 is therefore by definition zero. It might be that lead containing material is recycled and the resulting product is exported. In that case the lead containing (post consumer) waste would be kept separate from lead free (post production) waste. This stream is modelled by increasing the amount of direct export C7. In this policy option it is possible that after several decades the lead concentration in the PVC waste has been lowered so far that the waste could be used again in recycling while still complying with the 0.1 % restriction threshold. It is assumed that recycling industry would not be rebuilt after recycling has been impossible for several decades.

Policy option 5B

Recyclable material is used until the lead concentration in the new products reaches a value of 95 % of the legislative maximum or the technical maximum. Because the lead concentration could vary according to the input waste convertors would keep a safety margin below the legislative maximum. We assume that a safety margin of 5 % would be enough. The technical maximum is given for each separate product type in table A3.10 in appendix 3.

A4.3.3 Assumptions per application

For each of the product types the model is used to calculate the lead concentration in the products. The different product types have different assumptions based on their specific properties. These assumptions are given in this paragraph.

Profiles

In contrast to Table A 3.10 the model assumes that profiles are only recycled into new profiles, even though 19 % of the profiles waste is estimated to be going to pipes. The profiles going into pipes are mainly non-window profiles with a lower lead content than window profiles. The lower lead concentration in non-window profiles is assumed not to influence the lead content of the recycled piping waste much. Below 25 % recycled content the lowered material prices of rPVC will not offset the extra investments needed for co-extrusion.

Pipes and fittings

Piping is only recycled into new piping. Below 25% recycled content the lowered material prices of rPVC will not offset the extra investments needed for co-extrusion.

Cable

In cables no recycled material is used as this might influence the insulation of the cable. The recycled cable material is used in other products such as flooring tiles in non-residential applications such as stables, warehouses, etc. and traffic cones. The latter application is not a building product and therefore cannot be made with rPVC in policy option 5B. It is assumed that all PVC cable waste can be recycled into non-residential floor covering.

Flooring

Technically PVC flooring can only contain up to 10 % of recycled material. As only a finite amount of flooring is made and more and more PVC flooring waste is arising, in a few years the maximum amount of recycled material that can be absorbed in flooring will be reached. As recycled flooring waste is already being used in other applications we assume that all PVC flooring waste that will be recycled can be used in these other applications without a limit.

Roofing

PVC roofing waste can be reused in new roofing material up to 12.5 %. The minimum recycled content is set at 10 % as below this percentage of recycled content the lowered material prices of rPVC will not offset the extra investments needed for co-extrusion. Any recycled PVC roofing waste not used into new roofing will be reused in another application within the definition of building materials, such as pond liner or animal floor covering.

Appendix

5

Impact identification tables

A5.1 Introduction

In order to identify the impacts of the different options tables 1, 2 and 3 in chapter 8 of the impact assessment guidelines (SEC(2009) 92) have been used. By filling in these tables a first screening is made of the possible impacts. The impact is based on two factors: likelihood and magnitude. The screening was made based on common sense of the researchers and input from stakeholders in the PVC industry. The purpose of these tables is to identify the theoretical biggest impacts and have only been used as a step in the impact assessment process. As they are used only to screen options the statements in the tables have not been verified piece by piece. In the quantitative analysis step the real impacts of the theoretical biggest impacts have been calculated. The full tables as they have been filled in during the assessment can be found in this Annex.

Option 2: Restriction on lead in products
In this option it would be prohibited to put on the market articles containing chemical lead compounds, when the content of the substance in the product's homogenous individual parts is greater or equal 0.1 % by weight.

	KEY QUESTIONS	Actor	Short term	Long term >5 years	Likelihood	Magnitude	Total importance
ECONOMIC IMPACTS							
Functioning of the internal market and competition							
	What impact (positive or negative) does the option have on the free movement of goods, services, capital and workers?		The legislation within Europe will be more harmonized between member states. Not allowed to place lead containing articles on the market.	Same as short term	High	Low	
	Will it lead to a reduction in consumer choice, higher prices due to less competition, the creation of barriers for new suppliers and service providers, the facilitation of anti-competitive behaviour or emergence of monopolies, market segmentation, etc.?		Consumers cannot buy recyclate containing articles anymore. Some barriers for new suppliers and service providers will be installed. No information yet about monopolies or market segmentation.	Consumers cannot buy recyclate containing articles anymore. Some barriers for new suppliers and service providers will be installed. No information yet about monopolies or market segmentation.	High	Low	
Competitiveness, trade and investment flows							
	What impact does the option have on the global competitive position of EU firms?	PVC resin producers	Lead containing substances are not needed for PVC resin production, hence no short term impact expected	In the long run PVC producers' license to market could be affected if PVC is not recycled.	Low	High	
		Stabilizer producers	As the use of lead stabilizer has almost been discontinued in the EU 27 t the impact will be limited.	No impact in EU 27 after 2015	Low	Low	

	KEY QUESTIONS	Actor	Short term	Long term >5 years	Likeli hood	Magni tude	Total importance
		PVC converters	Production of PVC articles is a locally based industry as the articles are usually bulky (contain a lot of air), making transport expensive. The import and export to and from Europe is small compared to the local production. Prices of feedstock will go up as the prices of virgin resin are higher than that of recycled PVC.	Small improvement in competitiveness as more knowledge has been gained about non-lead stabilizers. Loss of the secondary material market so higher costs for input materials. Competitive drawback for export to countries where Pb is still allowed	High	Medium	
		PVC recyclers	For recyclers the impact is high. As the recycled material cannot be used in articles to be placed on the European markets the PVC material might be exported to regions where it is legal to reuse the material.	Same as short term. Maybe a cost effective option for the removal of lead will emerge in the long run. This would imply that all the used articles will be incinerated or exported for recycling.	High	High	High
	Does it impact on productivity?	PVC resin producers	no	no	Low	Low	
		Stabilizer producers	no	no	Low	Low	
		PVC converters	Productivity of PVC producers might go down because of change to other stabilizer/pigment.	Same as short term.	Low	Low	
		PVC recyclers	Not Applicable: Recycling no longer possible!	no	Low	Low	
	What impact does the option have on trade barriers?		No impact	No impact	Low	Low	
	Does it provoke cross-border investment flows (including relocation of economic activity)?	PVC resin producers	no	no	Low	Low	
		Stabilizer producers	None or possible relocation of production outside the EU 27	no	Low	Low	
		PVC converters	No	No	Low	Low	
		PVC recyclers	Yes, recycling might go out of Europe	no different than short term	High	High	High
Operating costs and conduct of business/Small and Medium Enterprises							
	Will it impose additional adjustment, compliance or transaction costs on businesses?	PVC resin producers	No	No	Low	Low	

	KEY QUESTIONS	Actor	Short term	Long term >5 years	Likeli hood	Magni tude	Total importance
		Stabilizer producers	Small adjustment costs to other stabilizers	After some time the adjustment costs are sunk	High	Low	
		PVC converters	Yes to adjustment costs.	After some time the adjustment costs are sunk	High	Medium	
		PVC recyclers	Possibly significant: need to check if PVC contains lead? Adjustment to lead free input material	Costs for quality control/check for no Pb stays	High	Medium	
	How does the option affect the cost or availability of essential inputs (raw materials, machinery, labour, energy, etc.)?	PVC resin producers	no impact	no impact	Low	Low	
		Stabilizer producers	None to limited impact	None to limited impact	Low	Low	
		PVC converters	None to limited impact	None to limited impact	Low	Low	
		PVC recyclers	Machinery costs might go up if detection of Pb becomes necessary	After the initial phase the cost impact or the availability problem fades away	Low	Medium	
	Does it affect access to finance?		No change in access to finance	No change in access to finance	Low	Low	
	Does it impact on the investment cycle?		Slower amortization of recycling facilities due to lower amount processed.	After some years the amortization will be final	Medium	Low	
	Will it entail the withdrawal of certain products from the market? Is the marketing of products limited or prohibited?		Yes, lead containing products will be withdrawn. The market for lead containing products would be prohibited	Yes, lead containing products will be withdrawn. The market for lead containing products would be prohibited	High	Low	
	Will it entail stricter regulation of the conduct of a particular business?		Yes placing on the market of lead containing articles will be prohibited. Yes, recycling of lead containing material will be useless as the material cannot be used anymore in Europe.	Same as short term	High	High	High
	Will it lead to new or the closing down of businesses?	PVC resin producers	No impact	In long term license to operate could be affected	Low	Low	
		Stabilizer producers	Change to lead free is already in progress.	no long term impact	Medium	Low	
		PVC converters	Limited impact foreseen	Limited impact foreseen	Low	Low	
		PVC recyclers	Export of PVC waste will increase. Closing down: Recycling.	After >40 years recycling could start up again, though this is unlikely.	High	High	High

	KEY QUESTIONS	Actor	Short term	Long term >5 years	Likeli hood	Magni tude	Total importance
	Are some products or businesses treated differently from others in a comparable situation?	PVC converters	PVC articles producers that have already switched totally to alternative stabilizers might have an advantage.	Short term effect will fade out	medium	Low	
		PVC recyclers	Smaller companies might have more problems with the change to lead free recycling only.	bigger companies might survive better than smaller businesses as the investment to check on Pb containing or not might be too expensive at a small turnover	Medium	Medium	
Administrative burdens on businesses							
	Does it affect the nature of information obligations placed on businesses (for example, the type of data required, reporting frequency, the complexity of submission process)?		No information obligation.	No information obligation.	Low	Low	
	What is the impact of these burdens on SMEs in particular?		No information obligation.	No information obligation.	Low	Low	
Public authorities							
	Does the option have budgetary consequences for public authorities at different levels of government (national, regional, local), both immediately and in the long run?		Articles will have to be checked by the competent authority in order to enforce compliance. Initially this will take more resources.	Articles will have to be checked by the competent authority in order to enforce compliance. After some time the amount of resources will be less	Low	Low	
	Does it bring additional governmental administrative burden?		No administrative burden	No administrative burden	Low	Low	
	Does the option require the creation of new or restructuring of existing public authorities?		No creation or restructuring. In Europe each country has its own inspection body for products.	No creation or restructuring. In Europe each country has its own inspection body for products.	Low	Low	
Property rights							
	Are property rights affected (land, movable property, tangible/intangible assets)? Is acquisition, sale or use of property rights limited?		not applicable	not applicable	Low	Low	
	Or will there be a complete loss of property?		not applicable	not applicable	Low	Low	
Innovation and research							
	Does the option stimulate or hinder research and development?		Limited impact foreseen	Limited impact foreseen	Low	Low	

	KEY QUESTIONS	Actor	Short term	Long term >5 years	Likeli hood	Magni tude	Total importance
	Does it facilitate the introduction and dissemination of new production methods, technologies and products?		No real facilitation, more force to change of production process facilitates and disseminates new production methods, technology and products.	This opens business opportunities to invest in Pb sorting of PVC and might finally lead to removal of lead from PVC waste	High	Medium	
	Does it affect intellectual property rights (patents, trademarks, copyright, other know-how rights)?		No property rights are changed	No property rights are changed	Low	Low	
	Does it promote or limit academic or industrial research?		It might promote research as there will be a drive to find another recycling process.	It might promote research as there will be a drive to find another recycling process.	High	Low	
	Does it promote greater productivity/resource efficiency?		Lower resource efficiency.	Lower resource efficiency.	High	High	High
Consumers and households							
	Does the option affect the prices consumers pay?		Product prices might go up as a result of more costly raw materials and more expensive production process.	Cost price increase might go down in time	High	Low	
	Does it impact on consumers' ability to benefit from the internal market?		No	No	Low	Low	
	Does it have an impact on the quality and availability of the goods/services they buy, on consumer choice and confidence? (cf. in particular non-existing and incomplete markets – see Annex 8)		None foreseen	None foreseen	Medium	Low	
	Does it affect consumer information and protection?		No	No	Low	Low	
	Does it have significant consequences for the financial situation of individuals / households, both immediately and in the long run?		No significant financial consequences	No significant financial consequences	Low	Low	
	Does it affect the economic protection of the family and of children?		No significant financial consequences for family or children	No significant financial consequences for family or children	Low	Low	
Specific regions or sectors							
	Does the option have significant effects on certain sectors?	PVC resin producers	No	No	Low	Low	

	KEY QUESTIONS	Actor	Short term	Long term >5 years	Likeli hood	Magni tude	Total importance
		Stabilizer producers	No, switch to other stabilizers was already part of the voluntary commitment	No	Low	Low	
		PVC converters	No, switch to other stabilizers was already part of the voluntary commitment	No	Low	Low	
		PVC recyclers	End of business as product cannot be used anymore	In the long run recycling could be started again. However the knowhow will be gone. Once stopped there will most probably not be a restart.	High	High	High
	Will it have a specific impact on certain regions, for instance in terms of jobs created or lost?		Recycling in the EU is driven by lower skilled labour for the dismantling and sorting steps. Eastern European countries might be impacted more.	Recycling in the EU is driven by lower skilled labour for the dismantling and sorting steps. Eastern European countries might be impacted more.	High	Medium	
	Is there a single Member State, region or sector which is disproportionately affected (so-called 'outlier' impact)?		So far no outlier identified	So far no outlier identified	Low	Low	
Third countries and international relations							
	How does the option affect trade or investment flows between the EU and third countries? How does it affect EU trade policy and its international obligations, including in the WTO?		Seems to be not a big problem: http://www.wto.org/english/thewto_e/whatis_e/tif_e/agrm4_e.htm	Seems to be not a big problem: http://www.wto.org/english/thewto_e/whatis_e/tif_e/agrm4_e.htm	Low	Low	
	Does the option affect specific groups (foreign and domestic businesses and consumers) and if so in what way?		Not significantly	Not significantly	Low	Low	
	Does the option concern an area in which international standards, common regulatory approaches or international regulatory dialogues exist?		No	No	Low	Low	
	Does it affect EU foreign policy and EU/EC development policy?		Not relevant.	Not relevant	Low	Low	
	What are the impacts on third countries with which the EU has preferential trade arrangements?		No impact	No impact	Low	Low	

	KEY QUESTIONS	Actor	Short term	Long term >5 years	Likeli hood	Magni tude	Total importance
	Does it affect developing countries at different stages of development (least developed and other low-income and middle income countries) in a different manner?		Recycling might be exported to developing countries. Developing countries will receive the burden of our lead containing PVC waste but also jobs will be created	Recycling might be exported to developing countries. Developing countries will receive the burden of our lead containing PVC waste but also jobs will be created			
	Does the option impose adjustment costs on developing countries?		Yes. The producers in developing countries must adjust to the new regulation in order to export into the EU. That is: removing Pb from their products. There is no significant amount of import of PVC products from developing countries, except toys and consumer goods	Yes. The producers in developing countries must adjust to the new regulation. That is: removing Pb from their products. There is no significant amount of import of PVC products from developing countries, except toys and consumer goods	Low	Low	
	Does the option affect goods or services that are produced or consumed by developing countries?		The option affects goods that are produced and consumed in developing countries: PVC products	The option affects goods that are produced and consumed in developing countries: PVC products	Low	Low	
Macroeconomic environment							
	Does it have overall consequences of the option for economic growth and employment?		If recycling of PVC is decimated this will have an effect on economic growth and employment	If recycling of PVC is decimated this will have an effect on economic growth and employment	High	Medium	
	How does the option contribute to improving the conditions for investment and the proper functioning of markets?		No positive or negative contribution	No positive or negative contribution	Low	Low	
	Does the option have direct impacts on macro-economic stabilization?		No	No	Low	Low	
SOCIAL IMPACTS							
Employment and labour markets							
	Does the option facilitate new job creation?		Low impact foreseen	Low impact foreseen	Low	Low	
	Does it lead directly or indirectly to a loss of jobs?		Directly as recycling will be stopped jobs will be lost. Indirectly as export, and other types of processing emerges	Directly as recycling will be stopped jobs will be lost. Indirectly as export, and other types of processing emerges	High	High	High
	Does it have specific negative consequences for particular professions, groups of workers, or self-employed persons?		Positive influence on the health of people working with lead containing products.	Positive influence on the health of people working with lead containing products.	High	High	High

	KEY QUESTIONS	Actor	Short term	Long term >5 years	Likeli hood	Magni tude	Total importance
	Does it affect particular age groups?		No	No	Low	Low	
	Does it affect the demand for labour?		Yes demand for labour might go down.	Yes demand for labour might go down.	Medium	Medium	
	Does it have an impact on the functioning of the labour market?		No	No	Low	Low	
	Does it have an impact on the reconciliation between private, family and professional life?		No	No	Low	Low	
Standards and rights related to job quality							
	Does the option impact on job quality?		Less low skilled labour because of reduced recycling and less recyclate being used in co-extrusion.	Less low skilled labour because of reduced recycling and less recyclate being used in co-extrusion.	High	Low	
	Does the option affect the access of workers or job-seekers to vocational or continuous training?		not directly	not directly	Low	Low	
	Will it affect workers' health, safety and dignity?		Yes. Less exposure to lead compounds	Yes. Less exposure to lead compounds	High	Medium	
	Does the option directly or indirectly affect workers' existing rights and obligations, in particular as regards information and consultation within their undertaking and protection against dismissal?		No	No	Low	Low	
	Does it affect the protection of young people at work?		No, people of working age are not extra vulnerable.	No, people of working age are not extra vulnerable.	Low	Low	
	Does it directly or indirectly affect employers' existing rights and obligations?		no	no	Low	Low	
	Does it bring about minimum employment standards across the EU?		no	no	Low	Low	
	Does the option facilitate or restrict restructuring, adaptation to change and the use of technological innovations in the workplace?		no	no	Low	Low	
Social inclusion and protection of particular groups							

	KEY QUESTIONS	Actor	Short term	Long term >5 years	Likeli hood	Magni tude	Total importance
	Does the option affect access to the labour market or transitions into/out of the labour market?		no	no	Low	Low	
	Does it lead directly or indirectly to greater equality or inequality?		no	no	Low	Low	
	Does it affect equal access to services and goods?		no	no	Low	Low	
	Does it affect access to placement services or to services of general economic interest?		no	no	Low	Low	
	Does the option make the public better informed about a particular issue?		no	no	Low	Low	
	Does the option affect specific groups of individuals (for example the most vulnerable or the most at risk of poverty, children, women, elderly, the disabled, unemployed or ethnic, linguistic and religious minorities, asylum seekers), firms or other organizations (for example churches) or localities more than others?		Children are better protected, as well as unborn child (through pregnant women).	Children are better protected, as well as unborn child (through pregnant women).	High	Medium	
	Does the option significantly affect third country nationals?		Recycling of lead containing waste will be exported.	Recycling of lead containing waste will be exported.	High	Low	
Gender equality, equality treatment and opportunities, non -discrimination							
	Does the option affect the principle of non-discrimination, equal treatment and equal opportunities for all?		No	No	Low	Low	
	Does the option have a different impact on women and men?		Unborn child exposed through pregnant women are more sensitive to lead but they are by law not working in production. More men work in recycling businesses. More men work in stabilizer businesses. More men work in PVC production business	Unborn child exposed through pregnant women are more sensitive to lead but they are by law not working in production. More men work in recycling businesses. More men work in stabilizer businesses. More men work in PVC production business	Medium	Medium	
	Does the option promote equality between women and men?		no	no	Low	Low	

	KEY QUESTIONS	Actor	Short term	Long term >5 years	Likeli hood	Magni tude	Total importance
	Does the option entail any different treatment of groups or individuals directly on grounds of sex, racial or ethnic origin, religion or belief, disability, age, and sexual orientation? Or could it lead to indirect discrimination?		Children are more affected by lead. They are better protected.	Children are more affected by lead. They are better protected.	Medium	Low	
Individuals, private and family life, personal data							
	Does the option impose additional administrative requirements on individuals or increase administrative complexity?		No	No	Low	Low	
	Does the option affect the privacy, of individuals (including their home and communications)?		NA	No	Low	Low	
	Does it affect the right to liberty of individuals?		NA	No	Low	Low	
	Does it affect their right to move freely within the EU?		NA	No	Low	Low	
	Does it affect family life or the legal, economic or social protection of the family?		NA	No	Low	Low	
	Does it affect the rights of the child?		No, though it could be argued that the rights are upheld better because of a safer place to grow up	No, though it could be argued that the rights are upheld better because of a safer place to grow up	Low	Low	
	Does the option involve the processing of personal data or the concerned individual's right of access to personal data?		no	no	Low	Low	
Governance, participation, good administration, access to justice, media and ethics							
	Does the option affect the involvement of stakeholders in issues of governance as provided for in the Treaty and the new governance approach?		No	No	Low	Low	

	KEY QUESTIONS	Actor	Short term	Long term >5 years	Likeli hood	Magni tude	Total importance
	Are all actors and stakeholders treated on an equal footing, with due respect for their diversity? Does the option impact on cultural and linguistic diversity?		Yes to equal treatment, no to impact on diversity	Yes to equal treatment, no to impact on diversity	Low	Low	
	Does it affect the autonomy of the social partners in the areas for which they are competent? Does it, for example, affect the right of collective bargaining at any level or the right to take collective action?		no	no	Low	Low	
	Does the implementation of the proposed measures affect public institutions and administrations, for example in regard to their responsibilities?		The inspection bodies of the competent authority will have more responsibility to check if articles contain lead	The inspection bodies of the competent authority will have more responsibility to check if articles contain lead	High	Low	
	Will the option affect the individual's rights and relations with the public administration?		no	no	Low	Low	
	Does it affect the individual's access to justice?		no	no	Low	Low	
	Does it foresee the right to an effective remedy before a tribunal?		no	no	Low	Low	
	Does the option make the public better informed about a particular issue? Does it affect the public's access to information?		no	no	Low	Low	
	Does the option affect political parties or civic organizations?		no	no	Low	Low	
	Does the option affect the media, media pluralism and freedom of expression?		no	no	Low	Low	
	Does the option raise (bio) ethical issues (cloning, use of human body or its parts for financial gain, genetic research/testing, use of genetic information)?		no	no	Low	Low	

	KEY QUESTIONS	Actor	Short term	Long term >5 years	Likeli hood	Magni tude	Total importance
Public health and safety							
	Does the option affect the health and safety of individuals/populations, including life expectancy, mortality and morbidity, through impacts on the socio-economic environment (working environment, income, education, occupation, nutrition)?		No	No	Low	Low	
	Does the option increase or decrease the likelihood of health risks due to substances harmful to the natural environment?		Decrease the health risk, especially for children and unborn child.	Decrease the health risk, especially for children and unborn child.	High	High	High
	Does it affect health due to changes in the amount of noise, air, water or soil quality?		Soil, water and air quality will increase but most likely in the long term.	Soil, water and air quality will increase but most likely in the long term.	Medium	Low	
	Will it affect health due to changes energy use and/or waste disposal?		Yes	Yes	High	Low	
	Does the option affect lifestyle-related determinants of health such as diet, physical activity or use of tobacco, alcohol, or drugs?		No	No	Low	Low	
	Are there specific effects on particular risk groups (determined by age, gender, disability, social group, mobility, region, etc.)?		(unborn) children	(unborn) children	Medium	Medium	
Crime, Terrorism and Security							
	Does the option have an effect on security, crime or terrorism?		No	No	Low	Low	
	Does the option affect the criminal's chances of detection or his/her potential gain from the crime?		No	No	Low	Low	
	Is the option likely to increase the number of criminal acts?		NA	NA	Low	Low	
	Does it affect law enforcement capacity?		No	No	Low	Low	
	Will it have an impact on security interests?		No	No	Low	Low	

	KEY QUESTIONS	Actor	Short term	Long term >5 years	Likeli hood	Magni tude	Total importance
	Will it have an impact on the right to liberty and security, right to fair trial and the right of defence?		No	No	Low	Low	
	Does it affect the rights of victims of crime and witnesses?		No	No	Low	Low	
Access to and effects on social protection, health and educational systems							
	Does the option have an impact on services in terms of quality/access for all?		No	No	Low	Low	
	Does it have an effect on the education and mobility of workers (health, education, etc.)?		No	No	Low	Low	
	Does the option affect the access of individuals to public/private education or vocational and continuing training?		No	No	Low	Low	
	Does it affect the cross-border provision of services, referrals across borders and co-operation in border regions?		No	No	Low	Low	
	Does the option affect the financing / organization / access to social, health and care services?		No	No	Low	Low	
	Does it affect universities and academic freedom / self-governance?		No	No	Low	Low	
Culture							
	Does the proposal have an impact on the preservation of cultural heritage?		No	No	Low	Low	
	Does the proposal have an impact on cultural diversity?		No	No	Low	Low	
	Does the proposal have an impact on citizens' participation in cultural manifestations, or their access to cultural resources?		No	No	Low	Low	

	KEY QUESTIONS	Actor	Short term	Long term >5 years	Likeli hood	Magni tude	Total importance
Social impacts in third countries							
	Does the option have a social impact on third countries that would be relevant for overarching EU policies, such as development policy?		No	No	Low	Low	
	Does it affect international obligations and commitments of the EU arising from e.g. the ACP-EC Partnership Agreement or the Millennium Development Goals?		Export of lead containing PVC Would create jobs	Export of lead containing PVC would create jobs	High	Low	
	Does it increase poverty in developing countries or have an impact on income of the poorest populations?		Export of lead containing PVC would created jobs and hence increase incomes	Export of lead containing PVC would created jobs and hence increase incomes	High	Medium	
ENVIRONMENTAL IMPACTS							
The climate							
	Does the option affect the emission of greenhouse gases (e.g. carbon dioxide, methane etc.) into the atmosphere?		Yes: no more recycling means more use of virgin PVC resin, associated with higher GHG emissions	Yes: no more recycling means more use of virgin PVC resin, associated with higher GHG emissions	high	High	High
	Does the option affect the emission of ozone-depleting substances (CFCs, HCFCs .)?		No	No	Low	Low	
	Does the option affect our ability to adapt to climate change?		No	No	Low	Low	
Transport and the use of energy							
	Will the option increase/decrease energy and fuel needs/consumption?		Increase of energy use as recycling takes less energy than making virgin material.	Increase of energy use as recycling takes less energy than making virgin material.	High	High	High
	Does the option affect the energy intensity of the economy?		Yes, as PVC is used extensively in society and recycling will extensively reduce the amount of energy consumed in society. The energy intensity of the economy will go up. However compared to the total European energy usage, the impact will be small.	Yes, as PVC is used extensively in society and recycling will extensively reduce the amount of energy consumed in society. The energy intensity of the economy will go up. However compared to the total European energy usage, the impact will be small.	High	Low	

	KEY QUESTIONS	Actor	Short term	Long term >5 years	Likeli hood	Magni tude	Total importance
	Does the option affect the fuel mix (between coal, gas, nuclear, renewables etc.) used in energy production?		Not significantly	Not significantly	Low	Low	
	Will it increase or decrease the demand for transport (passenger or freight), or influence its modal split?		Yes More transport to third countries if PVC waste is exported	Yes More transport to third countries if PVC waste is exported	Medium	Low	
	Does it increase or decrease vehicle emissions?		Increase of transport so more vehicle emissions	Increase of transport so more vehicle emissions	Medium	Low	
Air quality							
	Does the option have an effect on emissions of acidifying, eutrophying, photochemical or harmful air pollutants that might affect human health, damage crops or buildings or lead to deterioration in the environment (soil or rivers etc.)?		In the short term the emission of lead is reduced minimally	Emission of lead is reduced	High	Low	
Biodiversity, flora, fauna and landscapes							
	Does the option reduce the number of species/varieties/races in any area (i.e. reduce biological diversity) or increase the range of species (e.g. by promoting conservation)?		Unknown. To be assessed outside of this study.	Unknown. To be assessed outside of this study.	?	?	
	Does it affect protected or endangered species or their habitats or ecologically sensitive areas?		Unknown. To be assessed outside of this study.	Unknown. To be assessed outside of this study.	?	?	
	Does it split the landscape into smaller areas or in other ways affect migration routes, ecological corridors or buffer zones?		No	No	Low	Low	
	Does the option affect the scenic value of protected landscape?		No	No	Low	Low	
Water quality and resources							
	Does the option decrease or increase the quality or quantity of freshwater and groundwater?		Could contribute to increase the quality. Unknown if this is in the short run	Same as short term Most likely increase the quality. Unknown if this is in the short run.	Medium	Low	

	KEY QUESTIONS	Actor	Short term	Long term >5 years	Likeli hood	Magni tude	Total importance
	Does it raise or lower the quality of waters in coastal and marine areas (e.g. through discharges of sewage, nutrients, oil, heavy metals, and other pollutants)?		More incineration will release lead.	More incineration will release lead.	Medium	Low	
	Does it affect drinking water resources?		Yes because it lowers the discharge of lead. Probably more in the long run	In the long run it might raise the quality of drinking water resources because the discharge of lead is lower	Medium	Low	
Soil quality or resources							
	Does the option affect the acidification, contamination or salinity of soil, and soil erosion rates?		Foreseen to be limited	In the long run less discharge of lead in the soil	Low	Low	
	Does it lead to loss of available soil (e.g. through building or construction works) or increase the amount of usable soil (e.g. through land decontamination)?		No	No	Low	Low	
Land use							
	Does the option have the effect of bringing new areas of land ('greenfields') into use for the first time?		No	No	Low	Low	
	Does it affect land designated as sensitive for ecological reasons? Does it lead to a change in land use (for example, the divide between rural and urban, or change in type of agriculture)?		No	No	Low	Low	
Renewable or non-renewable resources							
	Does the option affect the use of renewable resources (fish etc.) and lead to their use being faster than they can regenerate?		No	No	Low	Low	
	Does it reduce or increase use of non-renewable resources (groundwater, minerals etc.)?		Because recycling will be less, increase of the use of non-renewables, because the crude oil and salt are being used, as well as the other raw materials used to produce PVC resin and additives.	Because recycling will be less, increase of the use of non-renewables, because the crude oil and salt are being used, as well as the other raw materials used to produce PVC resin and additives.	High	High	High

	KEY QUESTIONS	Actor	Short term	Long term >5 years	Likeli hood	Magni tude	Total importance
The environmental consequences of firms and consumers							
	Does the option lead to more sustainable production and consumption?		No, it will lower recycling rates	Lower recycling rates	Medium	Medium	
	Does the option change the relative prices of environmental friendly and unfriendly products?		Yes, recycled material will be banned. Prices for virgin may go up.	Yes, recycled material will be banned. Prices for virgin may go up.	High	Medium	
	Does the option promote or restrict environmentally un/friendly goods and services through changes in the rules on capital investments, loans, insurance services etc.?		No	No	Low	Low	
	Will it lead to businesses becoming more or less polluting through changes in the way in which they operate?	PVC resin producers	No change	No change	Low	Low	
		Stabilizer producers	No change	No change	High	Low	
		PVC converters	Less polluting because less scrapping because no secondary material is used. Likely a marginal effect	Less polluting because less scrapping because no secondary material is used	Low	Low	
		PVC recyclers	Less polluting because less production or shut down	Less polluting because less production or shut down	High	Medium	
Waste production / generation / recycling							
	Does the option affect waste production (solid, urban, agricultural, industrial, mining, radioactive or toxic waste) or how waste is treated, disposed of or recycled?		No increase or decrease in waste produced. The waste treatment is changed a lot. No more recycling. Most likely more export?	No increase or decrease in waste produced. The waste treatment is changed a lot. No more recycling. Most likely more export? After 40+ years recycling could commence again	High	High	High
The likelihood or scale of environmental risks							
	Does the option affect the likelihood or prevention of fire, explosions, breakdowns, accidents and accidental emissions?		No accident. Concentrations in the plastic are too low, bound in the matrix.	No accident. Concentrations in the plastic are too low, bound in the matrix.	Low	Low	

	KEY QUESTIONS	Actor	Short term	Long term >5 years	Likeli hood	Magni tude	Total importance
	Does it affect the risk of unauthorized or unintentional dissemination of environmentally alien or genetically modified organisms?		No	No	Low	Low	
Animal welfare							
	Does the option have an impact on health of animals?		Same as human health.	Same as human health	Medium	Medium	
	Does the option affect animal welfare (i.e. humane treatment of animals)?		No evidence	No evidence	Low	Low	
	Does the option affect the safety of food and feed?		No	No	Low	Low	
International environmental impacts							
	Does the option have an impact on the environment in third countries that would be relevant for overarching EU policies, such as development policy?		If PVC is exported it could have an impact on the environment in third countries	If PVC is exported it could have an impact on the environment in third countries	Low	Low	

Option 5B Restriction on lead in products with an exemption for lead in building products with 1 % restriction limit for building products for a limited time
This option is comparable to option four: A prohibition of lead in articles with an exemption for lead in building products with a maximum lead content of 1 %. Piping for drinking water would be considered a non building material. The exemption would be reviewed after a specified time.

	KEY QUESTIONS	**Actor**	**Short term**	**Long term >5 years**	**Likeli hood**	**Magni tude**	**Total importance**
ECONOMIC IMPACTS							
Functioning of the internal market and competition							
	What impact (positive or negative) does the option have on the free movement of goods, services, capital and workers?		The legislation within Europe will be more harmonized between member states. Not allowed to place lead containing articles on the market.	Same as short term	High	Low	
	Will it lead to a reduction in consumer choice, higher prices due to less competition, the creation of barriers for new suppliers and service providers, the facilitation of anti-competitive behaviour or emergence of monopolies, market segmentation, etc.?		Consumers cannot buy recyclate containing articles anymore except construction products. Some barriers for new suppliers and service providers will be installed. No information yet about monopolies or market segmentation.	Consumers cannot buy recyclate containing articles anymore, except construction products. Some barriers for new suppliers and service providers will be installed. No information yet about monopolies or market segmentation.	High	Low	
Competitiveness, trade and investment flows							
	What impact does the option have on the global competitive position of EU firms?	PVC resin producers	Lead containing substances are not needed for PVC resin production, hence no short term impact expected	In the long run PVC producers' license to market could be affected if PVC is not recycled.	Low	High	
		Stabilizer producers	As the use of lead stabilizer has almost been discontinued in the EU 27 t the impact will be limited.	No impact in EU 27 after 2015	Low	Low	

	KEY QUESTIONS	Actor	Short term	Long term >5 years	Likeli hood	Magni tude	Total importance
		PVC converters	Production of PVC articles is a locally based industry as the articles are usually bulky (contain a lot of air), making transport expensive. The import and export to and from Europe is small compared to the local production. Prices of feedstock will go up as the prices of virgin resin are higher than that of recycled PVC. However recycling of the biggest applications will still be possible.	Production of PVC articles is a locally based industry as the articles are usually bulky (contain a lot of air), making transport expensive. The import and export to and from Europe is small compared to the local production. Prices of feedstock will go up as the prices of virgin resin are higher than that of recycled PVC. However recycling of the biggest applications will still be possible.	High	Medium	
		PVC recyclers	For recyclers the impact is medium. As the recycled material cannot be used in all articles to be placed on the European markets, some PVC material might be exported to regions where it is legal to reuse the material. In the applications where large volumes are being recycled impact will be small.	Same as short term. Maybe a cost effective option for the removal of lead will emerge in the long run. This would imply that all the used articles will be incinerated or exported for recycling.	Medium	Medium	
	Does it impact on productivity?	PVC resin producers	no	no	Low	Low	
		Stabilizer producers	no	no	Low	Low	
		PVC converters	Productivity of PVC producers might go up because no recyclate is being used.	Same as short term.	Low	Low	
		PVC recyclers	Yes a more stringent screening might be necessary.	Yes a more stringent screening might be necessary.	Low	Low	
	What impact does the option have on trade barriers?		No impact	No impact	Low	Low	
	Does it provoke cross-border investment flows (including relocation of economic activity)?	PVC resin producers	no	no	Low	Low	
		Stabilizer producers	None or possible relocation of production outside the EU 27	no	Low	Low	
		PVC converters	No	No	Low	Low	
		PVC recyclers	No	No	Low	Low	Low

	KEY QUESTIONS	Actor	Short term	Long term >5 years	Likeli hood	Magni tude	Total importance
Operating costs and conduct of business/Small and Medium Enterprises							
	Will it impose additional adjustment, compliance or transaction costs on businesses?	PVC resin producers	No	No	Low	Low	
		Stabilizer producers	No, switch has been made	No, switch has been made	low	Low	
		PVC converters	Yes to adjustment costs.	After some time the adjustment costs are sunk	High	Low	
		PVC recyclers	Instrumentation costs might go up if detection of Pb becomes necessary.	After the initial phase the costs will be small.	Low	Medium	
	How does the option affect the cost or availability of essential inputs (raw materials, machinery, labour, energy, etc.)?	PVC resin producers	no impact	no impact	Low	Low	
		Stabilizer producers	None to limited impact	None to limited impact	Low	Low	
		PVC converters	None to limited impact	None to limited impact	Low	Low	
		PVC recyclers	Instrumentation costs might go up if detection of Pb becomes necessary	After the initial phase the cost impact or the availability problem fades away	Low	Medium	
	Does it affect access to finance?		No change in access to finance	No change in access to finance	Low	Low	
	Does it impact on the investment cycle?		Slower amortization of recycling facilities due to lower amount processed.	After some years the amortization will be final	Medium	Low	
	Will it entail the withdrawal of certain products from the market? Is the marketing of products limited or prohibited?		Yes, lead containing products will be withdrawn, except construction products. The market for most lead containing products would be prohibited	Yes, lead containing products will be withdrawn, except construction products. The market for most lead containing products is prohibited	High	Low	
	Will it entail stricter regulation of the conduct of a particular business?		Yes, production of many lead containing articles will be prohibited. Yes, recycling of lead containing material will be regulated.	Same as short term	High	Medium	
	Will it lead to new or the closing down of businesses?	PVC resin producers	No impact	In long term license to operate could be affected	Low	Low	
		Stabilizer producers	Change to lead free is already in progress.	no long term impact	Medium	Low	
		PVC converters	Limited impact foreseen	Limited impact foreseen	Low	Low	

	KEY QUESTIONS	Actor	Short term	Long term >5 years	Likeli hood	Magni tude	Total importance
		PVC recyclers	As the demand for secondary material might fall, some recyclers will be in bad weather. Export of PVC waste will most likely increase.	After >40 years recycling could start up again, though this is unlikely.	High	Medium	
	Are some products or businesses treated differently from others in a comparable situation?	PVC converters	PVC articles producers that have already switched totally to alternative stabilizers might have an advantage.	Short term effect will fade out	medium	Low	
		PVC recyclers	Smaller companies might have more problems with the change to lead free recycling only.	Bigger companies might survive better than smaller businesses as the investment to check on Pb containing or not might be to expensive at a small turnover	Medium	Medium	
Administrative burdens on businesses							
	Does it affect the nature of information obligations placed on businesses (for example, the type of data required, reporting frequency, the complexity of submission process)?		No information obligation.	No information obligation.	Low	Low	
	What is the impact of these burdens on SMEs in particular?		No information obligation.	No information obligation.	Low	Low	
Public authorities							
	Does the option have budgetary consequences for public authorities at different levels of government (national, regional, local), both immediately and in the long run?		Articles will have to be checked by the competent authority in order to enforce compliance. Initially this will take more resources.	Articles will have to be checked by the competent authority in order to enforce compliance. After some time the amount of resources will be less	Low	Low	
	Does it bring additional governmental administrative burden?		No administrative burden	No administrative burden	Low	Low	
	Does the option require the creation of new or restructuring of existing public authorities?		No creation or restructuring. In Europe each country has its own inspection body for products.	No creation or restructuring. In Europe each country has its own inspection body for products.	Low	Low	
Property rights							
	Are property rights affected (land, movable property, tangible/intangible assets)? Is acquisition, sale or use of property rights limited?		not applicable	not applicable	Low	Low	
	Or will there be a complete loss of property?		not applicable	not applicable	Low	Low	

	KEY QUESTIONS	Actor	Short term	Long term >5 years	Likeli hood	Magni tude	Total importance
Innovation and research							
	Does the option stimulate or hinder research and development?		Limited impact foreseen	Limited impact foreseen	low	Low	
	Does it facilitate the introduction and dissemination of new production methods, technologies and products?		No real facilitation, more force to change of production process facilitates and disseminates new production methods, technology and products.	This opens business opportunities to invest in Pb sorting of PVC and might finally lead to removal of lead from PVC waste	Medium	Medium	
	Does it affect intellectual property rights (patents, trademarks, copyright, other know-how rights)?		No property rights are changed	No property rights are changed	Low	Low	
	Does it promote or limit academic or industrial research?		It might promote research as there will be a drive to find another recycling process.	It might promote research as there will be a drive to find another recycling process.	High	Low	
	Does it promote greater productivity/resource efficiency?		Lower resource efficiency. However the most important applications for recycling could still use recycled material. The use of capacity might be lower.	Lower resource efficiency. However the most important applications for recycling could still use recycled material. The use of capacity might be lower.	High	Medium	
Consumers and households							
	Does the option affect the prices consumers pay?		Product prices might go up as a result of more costly raw materials and more expensive production process.	Cost price increase might go down in time	High	Low	
	Does it impact on consumers' ability to benefit from the internal market?		No	No	Low	Low	
	Does it have an impact on the quality and availability of the goods/services they buy, on consumer choice and confidence? (cf. in particular non-existing and incomplete markets – see Annex 8)		None foreseen	Not foreseen	Medium	Low	
	Does it affect consumer information and protection?		No	No	Low	Low	
	Does it have significant consequences for the financial situation of individuals / households, both immediately and in the long run?		No significant financial consequences	No significant financial consequences	Low	Low	

	KEY QUESTIONS	Actor	Short term	Long term >5 years	Likeli hood	Magni tude	Total importance
	Does it affect the economic protection of the family and of children?		No significant financial consequences for family or children	No significant financial consequences for family or children	Low	Low	
Specific regions or sectors							
	Does the option have significant effects on certain sectors?	PVC resin producers	No	No	Low	Low	
		Stabilizer producers	No, switch to other stabilizers was already part of the voluntary commitment	No	Low	Low	
		PVC converters	No, switch to other stabilizers was already part of the voluntary commitment	No	Low	Low	
		PVC recyclers	Recyclers will have to take into account the amount of lead in their feedstock.	Recyclers will have to take into account the amount of lead in their feedstock. In the long run lead concentrations go down so far that there is no need to monitor this,	High	Medium	
	Will it have a specific impact on certain regions, for instance in terms of jobs created or lost?		Recycling in the EU is driven by lower skilled labour for the dismantling and sorting steps. Eastern European countries might be impacted more.	Recycling in the EU is driven by lower skilled labour for the dismantling and sorting steps. Eastern European countries might be impacted more.	High	Medium	
	Is there a single Member State, region or sector which is disproportionately affected (so-called 'outlier' impact)?		So far no outlier identified	So far no outlier identified	Low	Low	
Third countries and international relations							
	How does the option affect trade or investment flows between the EU and third countries? How does it affect EU trade policy and its international obligations, including in the WTO?		Seems to be not a big problem: http://www.wto.org/english/thewto_e/whatis_e/tif_e/agrm4_e.htm	Seems to be not a big problem: http://www.wto.org/english/thewto_e/whatis_e/tif_e/agrm4_e.htm	Low	Low	
	Does the option affect specific groups (foreign and domestic businesses and consumers) and if so in what way?		Not significantly	Not significantly	Low	Low	
	Does the option concern an area in which international standards, common regulatory approaches or international regulatory dialogues exist?		No	No	Low	Low	

	KEY QUESTIONS	Actor	Short term	Long term >5 years	Likeli hood	Magni tude	Total importance
	Does it affect EU foreign policy and EU/EC development policy?		Not relevant.	Not relevant			
	What are the impacts on third countries with which the EU has preferential trade arrangements?		No impact	No impact	Low	Low	
	Does it affect developing countries at different stages of development (least developed and other low-income and middle income countries) in a different manner?		Recycling might be exported to developing countries. Developing countries will receive the burden of our lead containing PVC waste but also jobs will be created	Recycling might be exported to developing countries. Developing countries will receive the burden of our lead containing PVC waste but also jobs will be created	Low	Low	
	Does the option impose adjustment costs on developing countries?		Yes. The producers in developing countries must adjust to the new regulation in order to export into the EU. That is: removing Pb from their products. There is no significant amount of import of PVC products from developing countries, except toys and consumer goods	Yes. The producers in developing countries must adjust to the new regulation. That is: removing Pb from their products. There is no significant amount of import of PVC products from developing countries, except toys and consumer goods	Low	Low	
	Does the option affect goods or services that are produced or consumed by developing countries?		The option affects goods that are produced and consumed in developing countries: PVC products	The option affects goods that are produced and consumed in developing countries: PVC products	Low	Low	
Macroeconomic environment							
	Does it have overall consequences of the option for economic growth and employment?		Impact is assumed to be small	Impact is assumed to be small	High	Low	
	How does the option contribute to improving the conditions for investment and the proper functioning of markets?		No positive or negative contribution	No positive or negative contribution	Low	Low	
	Does the option have direct impacts on macro-economic stabilization?		No	No	Low	Low	
SOCIAL IMPACTS							
Employment and labour markets							
	Does the option facilitate new job creation?		Low impact foreseen	Low impact foreseen	Low	Low	
	Does it lead directly or indirectly to a loss of jobs?		As recycling is not hindered so much, the job loss or gain will be marginal	As recycling is not hindered so much, the job loss or gain will be marginal	Low	Low	

	KEY QUESTIONS	Actor	Short term	Long term >5 years	Likeli hood	Magni tude	Total importance
	Does it have specific negative consequences for particular professions, groups of workers, or self-employed persons?		The lead reducing impact will have a small positive effect on the health of people working with lead and lead containing mixtures in. However, in recycling there might be a small job loss.	Positive influence on the health of people working with lead containing products.	Medium	Medium	
	Does it affect particular age groups?		No	No	Low	Low	
	Does it affect the demand for labour?		Yes demand for labour might go down.	Yes demand for labour might go down.	Medium	Low	
	Does it have an impact on the functioning of the labour market?		No	No	Low	Low	
	Does it have an impact on the reconciliation between private, family and professional life?		No	No	Low	Low	
Standards and rights related to job quality							
	Does the option impact on job quality?		Less low skilled labour if recycling is reduced and less recyclate being used in co-extrusion. Size of this effect is assumed to be low.	Less low skilled labour if recycling is reduced and less recyclate being used in co-extrusion. Size of this effect is assumed to be low.	medium	Low	
	Does the option affect the access of workers or job-seekers to vocational or continuous training?		not directly	not directly	Low	Low	
	Will it affect workers' health, safety and dignity?		Yes. Less exposure to lead compounds	Yes. Less exposure to lead compounds	Medium	Low	
	Does the option directly or indirectly affect workers' existing rights and obligations, in particular as regards information and consultation within their undertaking and protection against dismissal?		No	No	Low	Low	
	Does it affect the protection of young people at work?		No, people of working age are not extra vulnerable.	No, people of working age are not extra vulnerable.	Low	Low	
	Does it directly or indirectly affect employers' existing rights and obligations?		no	no	Low	Low	
	Does it bring about minimum employment standards across the EU?		no	no	Low	Low	

	KEY QUESTIONS	Actor	Short term	Long term >5 years	Likeli hood	Magni tude	Total importance
	Does the option facilitate or restrict restructuring, adaptation to change and the use of technological innovations in the workplace?		no	no	Low	Low	
Social inclusion and protection of particular groups							
	Does the option affect access to the labour market or transitions into/out of the labour market?		no	no	Low	Low	
	Does it lead directly or indirectly to greater equality or inequality?		no	no	Low	Low	
	Does it affect equal access to services and goods?		no	no	Low	Low	
	Does it affect access to placement services or to services of general economic interest?		no	no	Low	Low	
	Does the option make the public better informed about a particular issue?		no	no	Low	Low	
	Does the option affect specific groups of individuals (for example the most vulnerable or the most at risk of poverty, children, women, elderly, the disabled, unemployed or ethnic, linguistic and religious minorities, asylum seekers), firms or other organizations (for example churches) or localities more than others?		Children are better protected, as well as unborn child (through pregnant women).	Children are better protected, as well as unborn child (through pregnant women).	High	Medium	
	Does the option significantly affect third country nationals?		Recycling of lead containing waste will probably be exported.	Recycling of lead containing waste will probably be exported.	High	Low	
Gender equality, equality treatment and opportunities, non -discrimination							
	Does the option affect the principle of non-discrimination, equal treatment and equal opportunities for all?		No	No	Low	Low	

	KEY QUESTIONS	Actor	Short term	Long term >5 years	Likeli hood	Magni tude	Total importance
	Does the option have a different impact on women and men?		Unborn child exposed through pregnant women are more sensitive to lead but they are by law not working in production. More men work in recycling businesses. More men work in stabilizer businesses. More men work in PVC production business	Pregnant women are more sensitive to lead poisoning. More men work in recycling businesses. More men work in stabilizer businesses. More men work in PVC production business	Medium	Medium	
	Does the option promote equality between women and men?		no	no	Low	Low	
	Does the option entail any different treatment of groups or individuals directly on grounds of sex, racial or ethnic origin, religion or belief, disability, age, and sexual orientation? Or could it lead to indirect discrimination?		Children are more affected by lead. They are better protected.	Children are more affected by lead. They are better protected.	Medium	Low	
Individuals, private and family life, personal data							
	Does the option impose additional administrative requirements on individuals or increase administrative complexity?		No	No	Low	Low	
	Does the option affect the privacy, of individuals (including their home and communications)?		NA	No	Low	Low	
	Does it affect the right to liberty of individuals?		NA	No	Low	Low	
	Does it affect their right to move freely within the EU?		NA	No	Low	Low	
	Does it affect family life or the legal, economic or social protection of the family?		NA	NA	Low	Low	
	Does it affect the rights of the child?		No, though it could be argued that the rights are upheld better because of a safer place to grow up	No, though it could be argued that the rights are upheld better because of a safer place to grow up	Low	Low	
	Does the option involve the processing of personal data or the concerned individual's right of access to personal data?		no	no	Low	Low	

	KEY QUESTIONS	Actor	Short term	Long term >5 years	Likeli hood	Magni tude	Total importance
Governance, participation, good administration, access to justice, media and ethics							
	Does the option affect the involvement of stakeholders in issues of governance as provided for in the Treaty and the new governance approach?		No	No	Low	Low	
	Are all actors and stakeholders treated on an equal footing, with due respect for their diversity? Does the option impact on cultural and linguistic diversity?		Yes to equal treatment, no to impact on diversity	Yes to equal treatment, no to impact on diversity	Low	Low	
	Does it affect the autonomy of the social partners in the areas for which they are competent? Does it, for example, affect the right of collective bargaining at any level or the right to take collective action?		no	no	Low	Low	
	Does the implementation of the proposed measures affect public institutions and administrations, for example in regard to their responsibilities?		The inspection bodies of the competent authority will have more responsibility to check if articles contain lead	The inspection bodies of the competent authority will have more responsibility to check if products contain lead	High	Medium	
	Will the option affect the individual's rights and relations with the public administration?		no	no	Low	Low	
	Does it affect the individual's access to justice?		no	no	Low	Low	
	Does it foresee the right to an effective remedy before a tribunal?		no	no	Low	Low	
	Does the option make the public better informed about a particular issue? Does it affect the public's access to information?		no	no	Low	Low	
	Does the option affect political parties or civic organizations?		no	no	Low	Low	
	Does the option affect the media, media pluralism and freedom of expression?		no	no	Low	Low	

	KEY QUESTIONS	Actor	Short term	Long term >5 years	Likeli hood	Magni tude	Total importance
	Does the option raise (bio) ethical issues (cloning, use of human body or its parts for financial gain, genetic research/testing, use of genetic information)?		no	no	Low	Low	
Public health and safety							
	Does the option affect the health and safety of individuals/populations, including life expectancy, mortality and morbidity, through impacts on the socio-economic environment (working environment, income, education, occupation, nutrition)?		No	No	Low	Low	
	Does the option increase or decrease the likelihood of health risks due to substances harmful to the natural environment?		Decrease the health risk, especially for children and unborn child.	Decrease the health risk, especially for children and unborn child.	High	Medium	High
	Does it affect health due to changes in the amount of noise, air, water or soil quality?		Soil, water and air quality will increase but most likely in the long term.	Soil, water and air quality will increase but most likely in the long term.	Medium	Low	
	Will it affect health due to changes energy use and/or waste disposal?		Yes	Yes	High	Low	
	Does the option affect lifestyle-related determinants of health such as diet, physical activity or use of tobacco, alcohol, or drugs?		No	No	Low	Low	
	Are there specific effects on particular risk groups (determined by age, gender, disability, social group, mobility, region, etc.)?		Children	Children	Medium	Medium	
Crime, Terrorism and Security							
	Does the option have an effect on security, crime or terrorism?		No	No	Low	Low	
	Does the option affect the criminal's chances of detection or his/her potential gain from the crime?		No	No	Low	Low	

	KEY QUESTIONS	Actor	Short term	Long term >5 years	Likeli hood	Magni tude	Total importance
	Is the option likely to increase the number of criminal acts?		NA	NA	High	Low	
	Does it affect law enforcement capacity?		No	No	Low	Low	
	Will it have an impact on security interests?		No	No	Low	Low	
	Will it have an impact on the right to liberty and security, right to fair trial and the right of defence?		No	No	Low	Low	
	Does it affect the rights of victims of crime and witnesses?		No	No	Low	Low	
Access to and effects on social protection, health and educational systems							
	Does the option have an impact on services in terms of quality/access for all?		No	No	Low	Low	
	Does it have an effect on the education and mobility of workers (health, education, etc.)?		No	No	Low	Low	
	Does the option affect the access of individuals to public/private education or vocational and continuing training?		Decrease of lead content in consumer products is expected to have a positive impact on IQ	Decrease of lead content in consumer products is expected to have a positive impact on IQ	Medium	Medium	
	Does it affect the cross-border provision of services, referrals across borders and co-operation in border regions?		No	No	Low	Low	
	Does the option affect the financing / organization / access to social, health and care services?		No	No	Low	Low	
	Does it affect universities and academic freedom / self-governance?		No	No	Low	Low	
Culture							
	Does the proposal have an impact on the preservation of cultural heritage?		No	No	Low	Low	
	Does the proposal have an impact on cultural diversity?		No	No	Low	Low	

	KEY QUESTIONS	Actor	Short term	Long term >5 years	Likeli hood	Magni tude	Total importance
	Does the proposal have an impact on citizens' participation in cultural manifestations, or their access to cultural resources?		No	No	Low	Low	
Social impacts in third countries							
	Does the option have a social impact on third countries that would be relevant for overarching EU policies, such as development policy?		Export of lead containing PVC expected to increase, although much less than in option 2	Export of lead containing PVC expected to increase, although much less than in option 2	Medium	Low	
	Does it affect international obligations and commitments of the EU arising from e.g. the ACP-EC Partnership Agreement or the Millennium Development Goals?		No	No	Low	Low	
	Does it increase poverty in developing countries or have an impact on income of the poorest populations?		Increased export of PVC waste may create jobs in developing countries	Increased export of PVC waste may create jobs in developing countries	Medium	Low	
ENVIRONMENTAL IMPACTS							
The climate							
	Does the option affect the emission of greenhouse gases (e.g. carbon dioxide, methane etc.) into the atmosphere?		Yes: Less recycling means more use of virgin PVC resin, associated with higher GHG emissions. The effect is small however as recycling is hindered only marginally.	Yes: Less recycling means more use of virgin PVC resin, associated with higher GHG emissions. The effect is small however as recycling is hindered only marginally.	Medium	Medium	Medium
	Does the option affect the emission of ozone-depleting substances (CFCs, HCFCs .)?		No	No	Low	Low	
	Does the option affect our ability to adapt to climate change?		No	No	Low	Low	
Transport and the use of energy							
	Will the option increase/decrease energy and fuel needs/consumption?		Increase of energy use as recycling takes less energy than making virgin material, but the impact will be much lower than in option 2.	Increase of energy use as recycling takes less energy than making virgin material, but the impact will be much lower than in option 2.	High	Medium	
	Does the option affect the energy intensity of the economy?		Effect will be small through loss of recycling.	Effect will be small through loss of recycling.	Medium	Low	

	KEY QUESTIONS	Actor	Short term	Long term >5 years	Likeli hood	Magni tude	Total importance
	Does the option affect the fuel mix (between coal, gas, nuclear, renewables etc.) used in energy production?		Not significantly	Not significantly	Low	Low	
	Will it increase or decrease the demand for transport (passenger or freight), or influence its modal split?		More transport to third countries if more PVC waste is exported. No high impact expected.	More transport to third countries if more PVC waste is exported. No high impact expected.	Medium	Low	
	Does it increase or decrease vehicle emissions?		No significant impact expected	No significant impact expected	Low	Low	
Air quality							
	Does the option have an effect on emissions of acidifying, eutrophying, photochemical or harmful air pollutants that might affect human health, damage crops or buildings or lead to deterioration in the environment (soil or rivers etc.)?		In the short term the emission of lead is reduced minimally	Emission of lead is reduced because less lead will be present in society.	High	Low	
Biodiversity, flora, fauna and landscapes							
	Does the option reduce the number of species/varieties/races in any area (i.e. reduce biological diversity) or increase the range of species (e.g. by promoting conservation)?		Unknown. To be assessed outside of this study.	Unknown. To be assessed outside of this study.	?	?	
	Does it affect protected or endangered species or their habitats or ecologically sensitive areas?		Unknown. To be assessed outside of this study.	Unknown. To be assessed outside of this study.	?	?	
	Does it split the landscape into smaller areas or in other ways affect migration routes, ecological corridors or buffer zones?		No	No	Low	Low	
	Does the option affect the scenic value of protected landscape?		No	No	Low	Low	
Water quality and resources							
	Does the option decrease or increase the quality or quantity of freshwater and groundwater?		Could contribute to increase the quality. Unknown if this is in the short run	Same as short term Most likely increase the quality. Unknown if this is in the short run.	Medium	Low	

	KEY QUESTIONS	Actor	Short term	Long term >5 years	Likeli hood	Magni tude	Total importance
	Does it raise or lower the quality of waters in coastal and marine areas (e.g. through discharges of sewage, nutrients, oil, heavy metals, and other pollutants)?		More incineration will release lead.	More incineration will release lead.	Medium	Low	
	Does it affect drinking water resources?		Yes because it lowers the discharge of lead. Probably more in the long run	In the long run it might raise the quality of drinking water resources because the discharge of lead is lower	Medium	Low	
Soil quality or resources							
	Does the option affect the acidification, contamination or salinity of soil, and soil erosion rates?		Foreseen to be limited	In the long run less discharge of lead in the soil, but more emission form waste incinerators.	Low	Low	
	Does it lead to loss of available soil (e.g. through building or construction works) or increase the amount of usable soil (e.g. through land decontamination)?		No	No	Low	Low	
Land use							
	Does the option have the effect of bringing new areas of land ('greenfields') into use for the first time?		No	No	Low	Low	
	Does it affect land designated as sensitive for ecological reasons? Does it lead to a change in land use (for example, the divide between rural and urban, or change in type of agriculture)?		No	No	Low	Low	
Renewable or non-renewable resources							
	Does the option affect the use of renewable resources (fish etc.) and lead to their use being faster than they can regenerate?		No	No	Low	Low	
	Does it reduce or increase use of non-renewable resources (groundwater, minerals etc.)?		Because recycling might be less, increase of the use of non-renewables, because the crude oil and salt are being used, as well as the other raw materials used to produce PVC resin and additives.	Because recycling might be less, increase of the use of non-renewables, because the crude oil and salt are being used, as well as the other raw materials used to produce PVC resin and additives.	Medium	Medium	Medium

	KEY QUESTIONS	Actor	Short term	Long term >5 years	Likeli hood	Magni tude	Total importance
The environmental consequences of firms and consumers							
	Does the option lead to more sustainable production and consumption?		No, it will most likely lower recycling rates somewhat	No, it will most likely lower recycling rates somewhat	Low	Low	
	Does the option change the relative prices of environmental friendly and unfriendly products?		Yes, recycled material might be used less. Prices for virgin may go up.	Yes, recycled material might be used less. Prices for virgin may go up.	Medium	Low	
	Does the option promote or restrict environmentally un/friendly goods and services through changes in the rules on capital investments, loans, insurance services etc.?		No	No	Low	Low	
	Will it lead to businesses becoming more or less polluting through changes in the way in which they operate?	PVC resin producers	No change	No change	Low	Low	
		Stabilizer producers	No change, as lead stabilisers will be phased out by 2015	No change, as lead stabilisers will be phased out by 2015	High	Low	
		PVC converters	Less polluting because less scrapping because no secondary material is used. Likely a marginal effect	Less polluting because less scrapping because no secondary material is used	Low	Low	
		PVC recyclers	Less polluting because less production or shut down	Less polluting because less production or shut down	High	Medium	
Waste production / generation / recycling							
	Does the option affect waste production (solid, urban, agricultural, industrial, mining, radioactive or toxic waste) or how waste is treated, disposed of or recycled?		No increase or decrease in waste produced. The waste treatment is changed marginally. Maybe more export?	No increase or decrease in waste produced. The waste treatment is changed marginally. Maybe more export? After 40+ years recycling could commence again	Medium	Low	
The likelihood or scale of environmental risks							
	Does the option affect the likelihood or prevention of fire, explosions, breakdowns, accidents and accidental emissions?		No accident. Concentrations in the plastic are too low, bound in the matrix.	No accident. Concentrations in the plastic are too low, bound in the matrix.	Low	Low	

	KEY QUESTIONS	Actor	Short term	Long term >5 years	Likeli hood	Magni tude	Total importance
	Does it affect the risk of unauthorized or unintentional dissemination of environmentally alien or genetically modified organisms?		No	No	Low	Low	
Animal welfare							
	Does the option have an impact on health of animals?		Same as human health.	Same as human health	Medium	Medium	
	Does the option affect animal welfare (i.e. humane treatment of animals)?		No evidence	No evidence	Low	Low	
	Does the option affect the safety of food and feed?		No	No	Low	Low	
International environ-mental impacts							
	Does the option have an impact on the environment in third countries that would be relevant for overarching EU policies, such as development policy?		If PVC waste is exported it could have an impact on the environment in third countries	If PVC waste is exported it could have an impact on the environment in third countries	Low	Low	

Appendix

6

Choice of factors to calculate impact factors from distribution over waste management options

A6.1 Introduction

Chapter 5 describes the indicators that represent the impacts the different policy options have on society and the environment. In order to calculate these indicators the distribution of the available post consumer waste over the disposal options was calculated as described in appendix 4. Based on the distribution the indicators are calculated as explained in this appendix.

A6.2 Effect on recyclers

Potentially restricting the use of lead has a direct impact on recyclers in Europe. In order to estimate the impact, information is needed about the number of recyclers and the effect a restriction on lead in PVC articles might have on the business. An interview was held with a recycler in the Netherlands and information on other recyclers was researched on the internet.
In total information was collected for six recyclers [Toensmeier, Deceuninck, Merrit, Van Werven, Vinyloop, Veka Umwelt, Veka France].

Table A6.1 Information about recyclers

Plant	Throughput (t)	Number of employees	Employee/tonne
Deceuninck	20 000	13	0.00065
Merrit	12 000	15	0.00125
Toensmeier	60 000	300	0.005
Van Werven	40 000	120	0.003
Veka Umwelt Technik	50 000	110	0.0022
Veka SAS France	25 000	45	0.0018
Vinyloop	10 000	16	0.0016
Average	**31 000**	**88**	**0.0022**

The numbers in table A6.1 have a relatively large distribution. This might be the result of the size of the recycling plant and the organization behind the plant. The figures for Deceuninck and Merrit only give the number of employees in the recycling plant itself. The other companies have probably included the personnel for transport, handling and other related tasks.

Furthermore Recovinyl was contacted for an estimation of the number of companies in post consumer PVC waste recycling.

A total of 130 recycling companies are registered at this time with Recovinyl. About 50 companies recycle rigid post consumer PVC waste. The majority recycles plasticized post consumer PVC waste such as cable and film. According to Recovinyl most companies have specialized in PVC recycling, which means that when recycling is blocked these companies will be out of business. The size of recycling companies varies widely. The companies given in Table A6.1 are among the biggest companies. For rigid post consumer PVC waste the top 10 companies recycle about 55% of the total. This means that on average the throughput per company is much smaller than the average in Table A6.1. The average throughput for a recycling company can be found by dividing the total recycling of post consumer PVC waste which is around 350 ktonnes by the number of PVC recycling companies 130. This gives an average throughput of approximately 2.7 ktonnes per year.

A6.3 Financial effects

For the financial effects of the policy options we have used the values given in [VITO]. The VITO study calculates the effects of cadmium restrictions in a similar manner as this study calculates the effects of lead restrictions. VITO states that the added value for recyclers for a tonne of rPVC is EUR 50 – 100. The cost of producing one tonne of rPVC is around EUR 450 – 500 and the sales price is around EUR 500 – 600. Convertors have a benefit from recycled material which is in the order of EUR 600 – 700. Virgin prices are around EUR 1,100 per tonne. Convertors however also make extra costs by using rPVC. The extra costs are estimated at around EUR 11 per tonne. The revenues of rPVC articles usually are a little (10-15%) lower than the sales price of virgin material. This last factor cannot be quantified properly it is therefore disregarded.

The total financial benefit of recycled PVC is estimated to lie between EUR 639 and EUR 789 per tonne of rPVC.

A6.4 Social effects

On average one employee will recycle 452 tonne per year. The figure is approximately comparable to 468 tonne per employee as used in [VITO]. In this study we calculate the number of employees per tonne of recycled material based on the average data given in table A6.1.

Besides the employment of workers in recycling companies extra workers in converting should be taken into account. When a convertor is using recycled material extra supervision on the extruders is needed. Based on the piping industry the extra supervision is 25% extra operator time per line. This means 0,000 0035 fte per year per tonne of PVC waste.

Job loss because of less incineration or land filling is assumed to be negligible as PVC amounts in the total waste generation is negligible.

A6.5 Health effects

In paragraph A6.5.1 we describe the consequences of exposure to lead. There are several different exposure paths for lead in PVC to humans for different situations. The different situations are described and the exposure risk is estimated in the paragraphs A6.5.2 to A6.5.

A6.5.1 Consequences of exposure to lead

Acute, fatal lead poisoning hardly ever happens nowadays, as a result of improved medication and lowered exposure [Lanphear et al.]. In the USA paint is the major source of acute childhood lead poisoning, but this is not the case in Europe where leaded paint was used much less frequently than in the USA and has been banned since the end of the eighties. For European children, the biggest intake of lead is through diet and drink water [Bierkes et al.]. Uptake from water is not a trivial source of lead for young children in many communities according to [Lanphear et al.]. Water is becoming an increasingly important source of childhood lead exposure as other sources of lead intake decline. Imported products such as crayons and mini blinds of a lower quality that contain lead have received a lot of attention in the past. These products probably constitute a small source of lead intake for children [Lanphear et al.].

No threshold levels for the toxicological effects of lead have been identified; however the level for concern from the Center for Disease Control and prevention (CDC) in the USA is set at 100 µg/l (10 µg/dl). The WHO gives the same number but signifies it as an elevated level and states that loss of IQ was observed in children with blood levels below 10 µg/dl. The Reach registration dossiers for lead and its compounds put forward a DNEL of 40 µg Pb/dL for male workers, 30 for female and 10 for those in reproductive age (to protect the unborn child).

The exposure to lead is usually monitored through lead blood level tests. A European blood level baseline cannot be identified because blood lead levels vary according to age, sex, localization, occupation, lifestyle, etc. This has been extensively reviewed in the Voluntary Risk Assessment on lead [VRAR], where an overview is presented in Section 4.1.1.4.6. It can be concluded that lead blood levels have dropped considerably during the last decades, because of the discontinued use of leaded gasoline [Smolders et al.]. In Europe the mean lead level in blood for mature woman lies between 20 and 30 µg/l. The lead level in mature males is somewhat (20-30 %) higher. In general the younger the person the lower the lead levels in their blood.

Whereas acute high lead blood level might result in acute coma and even dead, the biggest impact on an (inter) national scale seems to be brain disorders as a result of exposure to lead. Disorders commonly thought to be related to lead include, reduced attention span, aggression, hyperactivity, learning disabilities, hearing loss, behavioural problems and impaired growth. Young children are especially vulnerable for the effects of lead exposure due to the development of their brains and other organs. Besides young children might have a higher lead uptake because of mouthing of non food objects. Unborn children can already have an elevated lead blood level as pregnant woman can pass on lead to the unborn child. Lead seems to be liberated from bone tissue during lactating, thus increasing the lead blood levels of mother and child [Woolf et al.].

As higher blood levels in children reduce the IQ, an average higher lead blood level in a population can influence the whole economy as lower IQ is associated with worse school performance, educational attainment and success in the labour market [WHO].

In the following paragraphs the exposure risks are discussed for different exposure scenario's, starting with the production of stabilizers up to the exposure during waste disposal and recycling.

A6.5.2 Production of stabilizers

During the production of stabilizers the workers could be exposed to lead. As the use of lead stabilizers for PVC in Europe is in the process of being phased out, the exposure will be drastically reduced/disappear after 2015. The exposure of workers to lead in the stabilizer production is well controlled. The blood lead levels are measured as part of national legislations and are compliant with the DNELs. The stabilizers are now increasingly marketed as low dusting "one packs" or pelletized to reduce dusting [Onga et al]. In all the policy options the exposure in this situation will be the same as the voluntary commitment to phase out lead in PVC will drastically reduce the exposure in this situation.

A6.5.3 Converting PVC resin and additives into a PVC compound and into PVC products
During compounding PVC resin powder is mixed with additives. Where handling of the stabilizer in the past has exposed workers to lead [Ho et al., Phoon et al.] this is different nowadays. The median blood lead level of workers in converting is below 40 µg Pb/dL. Even the 90 percentile is below 40 µg Pb/dL. Stabilizer is usually premixed with other additives, so called 'one pack'. This reduces dusting significantly. Besides, all operations are conducted in closed vessels [Fischbein et al.]. In all the policy options the exposure in this situation will be the same, as the voluntary commitment to phase out lead in PVC will reduce the exposure I this situation to zero.

A6.5.4 During installation
Many PVC s articles have to be installed before they can be used. For example: piping must be cut and glued in order to form a usable waste water sewer. During installation of the PVC products lead might be liberated. Little information is available about the exposure of workers to lead during installation of PVC products. One case is known where an electrician was in the habit to chew on PVC cable mantle, and thereby take up lead [CDC]. Meanwhile lead use in cable mantle has been largely discontinued as a consequence of RoHS regulation. This is not a common procedure so comparable cases will be scarce. As little information is available a comparison is made with the recycling industry. During recycling of lead containing PVC waste, the PVC material is handled in approximately the same way. The material is held in hand, and the material is cut or grinded, thus liberating small particles. The situation is obviously not totally comparable as during recycling the grinding/shredding operations will mostly be in covered machinery, while during installation the cutting operations will be mainly in the open. However, the exposure to the PVC particles will be usually shorter during installation than in a recycling plant. As no better information is available the installation situation is assumed to be comparable to the recycling operations. During recycling the exposure to lead was measured by a study of the German Federal institution for worker protection and worker medication. They found lead concentrations in the air which were at a maximum around 30 % of the allowed concentrations in air. The median value was 50 times lower than the norm, and 95 % of the measurements were below 10 % of the norm [Auffahrt et al.]. Based on the relation between air lead concentration and blood lead, the uptake in this situation can be assumed to be relatively low [Snee].
An indication for the maximum of the exposure can be found in the number of people with a BLL >25 µg/dL in the USA as a result of working in the construction sector (Building Construction General Contractors and Operative Builders). This number fluctuates between 24 and 105 in the years 2002 – 2008. Construction personnel are in contact with lead in much higher concentrations from other sources than the concentrations in PVC. Examples of these high concentrations are lead in lead sheeting and lead containing paint. Especially the latter is known to be a regular source of elevated BLL. It is unlikely that a large number of workers have an elevated BLL as a result of the use of lead containing PVC. In Europe the number of construction workers with elevated BLL's is assumed to be lower because lead containing paint was used less in Europe. The general exposure of workers to lead from PVC in the installation sector is considered negligible.

A6.5.5 During the life cycle of the product with consumers
Consumers come in contact with many different PVC products. In this paragraph we try to estimate the uptake of lead as a result of contact with PVC products. This is done in two ways. The first is a more theoretical approach where the exposure to lead from PVC is estimated based on exposure paths. The second is an epidemiological approach where we try to estimate the number of people with elevated BLL as a result of PVC products with consumers.

Lead emissions from PVC

In order for lead to be taken up by a person the lead has to be released from a source in a way it can be inhaled or swallowed. Uptake through the skin for the lead compounds used as stabilizers in PVC is very low [IOM]. In order for lead to be inhaled or swallowed, the lead has to be available at the surface of a PVC product. When lead is used as a stabilizer for PVC, lead usually is available at the surface of the product. A newly manufactured rigid PVC product has a thin coating of lubricant and stabilizer residues on the surface. This thin coating which is a result of the production procedure can come off the surface [NPG]. The lead deeper inside the rigid PVC products is generally assumed to be bound to the PVC matrix [NPG, Kiwa, and Oeki]

In order for the lead to be taken up in the body it has to be swallowed or inhaled. Different exposure paths can be identified for the products that are subject of this study.

1. Lead in drinking water as a result of lead in PVC drinking water pipes
2. Mouthing or eating (pica) of PVC articles
3. PVC product, to hand to mouth
4. PVC product to dust, and dust inhalation

For exposure path 1 it is shown that the use of lead containing drinking water pipes has no significant effect on the human health [NPG, Kiwa, and Oeki]. Besides, new drinking water pipes are lead free in Europe since 2007. Recycled material is only used in sewage pipes. According to the current REACH regulation these sewage pipes have to be coated with a thin layer of virgin material because of possible contamination with cadmium. This means no lead is present at the surface of the pipe. Elevation of blood lead levels because of the use of PVC piping therefore is unlikely. This exposure path does not lead to health degradation in practical situations.

Especially children, but also some groups of adults eat objects other than food, exposure path 2. This behaviour is called “pica”. When these objects are made of PVC with lead stabilizer, lead might be taken up. Generally PVC products will stay no more than several days in the body when swallowed, before they are released in the stool. As objects to be eaten are generally not very large, the surface area of PVC objects will be relatively small. During the stay in the body lead from the surface of the object could come off. Whereas this exposure path is probably the number one reason for children to have elevated BLL as a result of eating flaking lead containing paint, for PVC only one example could be found. An electrician was in the habit of chewing plastic wire coating for around 20 years. The PVC wire coating contained lead and as a result the electrician had elevated BLL [CDC]. It should be noted that wire coating is a plasticized form of PVC which most likely releases lead faster than rigid PVC. As eating of non food objects (pica) is usually associated with other types of materials than plastics the number of people having high BLL as a result of eating PVC must be considered very low. Besides when PVC building products are installed they are most difficult to eat. The effort needed to remove a PVC building product is probably greater than someone with a pica disorder would exert.

Besides eating non-food material especially children usually have a habit to mouth objects. An object is considered mouthable when an object “can be placed in the mouth”. This is further explained in a guideline of the European Commission [Mouthing Guideline]. The guideline explains that mouthing by children is assumed to be impossible if an article exceeds a size of 5 cm in all three dimensions.

If an article is smaller than 5 cm in at least one dimension, it can be taken into the mouth. However, the shape of the article, e.g. the existence of detachable or protruding parts and its resistance to compression or deformation also needs to be given consideration. Inaccessible parts of articles also cannot be taken into the month. Articles or parts of articles should be considered inaccessible if, during proper use or reasonably foreseeable improper use by children, they cannot be reached.

Recycled PVC is only used in a restricted number of applications. Most of these applications are not mouthable. The applications are given below together with comments on the mouthability.

Profiles

Profiles especially window profiles made from recycled PVC are mostly multilayer products. The recycled material is usually applied in an inner layer of the new profile. Therefore it is assumed to be inaccessible and therefore no exposure risk for recycled profiles exists.

Pipes & fittings

Indoor sewage pipes can be as small as 5 cm diameter but if they contain recyclate there would be a virgin layer on the outside and inside without lead, thus resulting in a negligible exposure risk.
Cable protection pipes can be made of 100% rPVC. These pipes are usually buried in the ground and are therefore inaccessible. In theory electrical conduit pipes can be made of 100 % rPVC. This application usually has a diameter smaller than 5 cm. In general electrical conduit pipes will be inaccessible because they are fixed in buildings and are often used behind cladding. Mouthing in the sense that the pipes will be put in the mouth by small children (0-36 months) is therefore unlikely. Electrical conduit pipes can also be used without cladding. When this is the case emphasis is put on the right colour of the piping. As a constant colour cannot be made with rPVC, electric conduit piping is made using virgin material as the piping is too thin to use a three layer system.
If rPVC would be used in electric conduit piping a limited risk might exist as electrical conduit pipes are known to be used as blowpipes by the youth. The lead migration out of these pipes based on data about lead containing drinking water pipes [KIWA] however is negligible. The maximum migration will be around 1 µg/day when a 12 mm blowpipe, both sides, is put in the mouth for 24 hours. For a child of 5 – 6 years old which weighs in at around 20 kg's the daily uptake would be around 0.050 µg/kg bw/day which is the Derived Minimal Effect Level according to [Annex XV restriction report]. As it is unlikely those blowpipes will be made with rPVC and it is equally unlikely that a child would put the blowpipe in its mouth during 24 hours, the daily uptake would be much lower, resulting in a negligible risk.

Cables

The recycled material of cables is never reused in cable material. The rPVC of cables is used in (Roofing) sheets, road cones, animal floor covering. These applications must be considered not mouthable.

Flooring

rPVC in flooring is only used in inner layers. Therefore exposure is negligible.

Roofing

rPVC in roofing is only used in inner layers or backing layers. Therefore exposure is negligible.

Exposure path 3 could be the case when a building product is exposed to the sun where it slowly deteriorates, thereby releasing the lead in the surface layer. When the surface layer is touched the lead might be transferred to the hands and further to the mouth. Nine cases have been reported where a child had elevated BLL as a result of contact with a PVC mini blind. During an investigation of the Consumer Product Safety Commission of the USA dust levels on mini blinds were reported up to 2,874 µg/sq.ft (approx 3.1 µg/cm^2) [NJDH, CPSC, Norman et al.]. The lead was assumed to be released at the surface of the mini blinds because of the influence of light and heat on the PVC material.

In a study performed by the Institute of Occupational Medicine [IOM] the maximum loading of lead that could be wiped from old and new PVC window profiles amounted to 0.45 µg/cm^2. The exposure of residents to lead was assumed to be minimal as levels of lead removed from lead stabilized PVC were low. The available lead is comparable to the dust lead loading norm in the USA which is 500 µg/ft^2 [HUD]. This converts to 0.54 µg/cm^2. These values are not directly comparable as the USA norm is an indication for the hazard of lead paint in houses whereas the study of the PVC window profiles was done in a laboratory setting.

The lead emissions from PVC products will be limited if the products are made by co-extrusion. In this case a virgin outer layer is present on the exterior of the product, effectively shielding the lead within the product from contact with humans. This is already the case for piping and in most cases for window profiles. It is unlikely that people regularly come in contact with roofing material, and PVC flooring in most cases has a wear layer which does not contain lead. Cables and wiring isn’t made with recycled PVC. This results in a very limited exposure of consumers to lead from recycled PVC.

Epidemiologic evidence

In the USA where lead poisoning is a much bigger issue because of the extended use of lead paint, regular BLL surveys are being made. In most cases where an elevated BLL was found a source or cause is identified. Based on this epidemiological evidence it can be concluded that most people who have a BLL>25 µg/dL in the USA are exposed to lead in their work environment.

In 2009 4,998 cases of BLL >25 µg/dL were identified in the USA [MMWR]. This may be an underestimate as not all states in the USA participated in the study and not all workers in a lead containing environment are tested. However the number of people who have a BLL >25 µg/dL as a result from non-occupational sources is only 328. In most cases the non-occupational source could be identified. Target shooting with lead containing ammunition was the most common source with over 100 cases. No group was classified as having elevated BLL as a result of exposure to lead in PVC products, though in some of the groupings this might have been the case. Pica, or eating non food objects was the source in 27 cases. No information is available on the foreign objects eaten by the patients in these cases. As a result eating of lead containing PVC cannot be excluded. As most of the literature refers to eating lead paint or dirt contaminated with lead, the number of cases with elevated BLL as a result of eating PVC will be the a minority to naught. Of the 328 non occupational cases 21 cases have been classified as 'Other non occupational exposure'. Again it cannot be excluded that these cases include cases that are a result of lead exposure from PVC. A total of 65 cases have an unidentified source. In total a maximum number of 113 cases could have been the result of lead from PVC though the actual number is likely to be only a few or maybe zero.

A6.5.6 Accidental exposure: Fire

Apart from some specific cases, lead is locked into the PVC matrix. The most likely cause of releasing the lead from the plastic would be when the PVC material is burning. In this case lead is emitted in the building, thereby exposing the inhabitants in the burning building. However lead is also emitted outside the building into the environment.

When inhabitants are exposed to a fire in a building, they would most likely be exposed for a short time to possible lead emissions. At maximum it will be a few minutes before a fire in a building would be so big that the smoke would kill the inhabitants if they have not escaped. The exposure time to any emitted lead will be so low the lead uptake will be negligible.

The emission of lead to the environment around the burning building will be in the very worst case all the lead contained in all PVC products in the building. However PVC exposed to high temperatures tends to char, thereby keeping most additives captured inside a carbon layer, and hence the amount of lead emitted from PVC products is most likely much smaller than the amount of lead emitted from other applications during building fires. For example the amount of lead used as lead sheets for water proofing was approximately 15 % of the used amount of lead in the EU15, whereas the use of lead for stabilization of plastics was around 2-3 % in 1998 [TNO]. Since 1998 the amount of lead used as stabilizer has decreased significantly, so the difference will be more distinct.

A6.5.7 During waste phase

After the lifetime of the PVC product the material comes in the waste phase. During this phase there is a low risk of lead uptake by humans, as the PVC waste is usually mixed in with other wastes. The concentrations of PVC in the total handled waste are relatively low. The PVC concentrations usually are around several percent [Ooms et al.], which means that lead concentrations resulting from PVC are negligible [Bernard et al.]. Besides, most wastes aren’t extensively handled manually. PVC in waste streams is usually not handled separately unless it is separated for recycling. The recycling situation is described separately in paragraph 6.9. In the waste phase the PVC material can be incinerated or landfilled. In both cases human exposure to lead from PVC is limited [Bernard et al., Meriowsky, and ARGUS].

A6.5.8 During recycling

The exposure of workers to lead from PVC during recycling is limited. This was studied by the German occupational health and occupational protection agency. The agency found lead concentrations in the air which were at a maximum around 30 % of the allowed concentrations in air. The median value was 50 times lower than the norm, and 95 % of the measurements were below 10 % of the norm [Auffahrt et al.]. Based on the relation between air lead concentration and blood lead, the uptake in this situation can be assumed to be relatively low [Snee].

A6.5.9 Summary of exposure to lead in PVC

Table A6.1

Phase	Exposure	Explanatory note
Production of stabilizers	Negligible	Stabilizer production will be discontinued for use in the EU by the end of 2015
Compounding and converting	Negligible	By the end of 2015 compounding of lead stabilizers will have ended.
Installation	Negligible	Lead exposure during installation can be considered comparable to exposure during recycling. During recycling negligible exposure was measured.
Consumers	Negligible?	Exposure to lead from rPVC is negligible as rPVC is inaccessible for mouthing when used in current applications.
Accidental exposure	Negligible	Exposure times are short and the amount of lead in PVC building materials is relatively small compared to other lead containing building materials.
Waste phase	Negligible	Lead concentration in mixed waste is too low to pose a risk. Contact and handling of waste is usually limited
Recycling	Negligible	Measurement of the lead concentrations in air in recycling facilities give values which are well below the norm.

A6.6 Greenhouse effect

The contribution of the different waste disposal options to the greenhouse effect is estimated as follows.
Recycling emits around 60 kg CO_2-eq per tonne of recycled material. However it prevents the production of virgin PVC. This avoids an emission of 1,960 kg CO_2-eq per tonne of recycled PVC. The net emission is therefore -1,900 kg CO_2-eq per tonne of recycled PVC [VITO]. As this is an important factor in the calculations other sources of information have been searched. In the Carbon Calculations over the Life Cycle of Industrial Activities tool (CCaL) the production of 1 tonne of PVC emits 2 113 kg of CO_2-eq. The recycling of 1 tonne of PVC white chips (Post consumer) emits 87 kg of CO_2-eq. This results in a net emission of -2 026 kg of CO_2-eq. This figure justifies using the VITO figure.

We would like to acknowledge the University of Manchester for the use of their CCal-tool.

Incineration of PVC emits 1,500 kg CO_2-eq per tonne of incinerated PVC. However, during incineration electricity and heat is generated which is applied elsewhere. Because of the electricity and heat generation in the incinerator the use of other fuels is prevented. Burning these other fuels would have resulted in an emission of 450 kg CO_2-eq per tonne of incinerated PVC waste. The net emission of incineration is therefore 1,050 kg CO_2-eq per tonne of incinerated PVC waste [VITO].

Landfilling emits only a small amount of green house gasses. The emission is estimated to be around 3 kg CO_2-eq per tonne of landfilled PVC waste [VITO].

When PVC waste is exported we assume the PVC waste would be recycled. However export to South East Asia will emit green house gasses too. The emission of green house gasses from transport is estimated to be around 187 kg CO_2-eq per tonne of transported PVC waste to South East Asia (12.000 sea miles [ports.com], 8,4 g CO_2/tonne-km [STREAM]). The net emission of export is therefore 1,713 kg CO_2-eq per tonne of exported PVC waste.

A6.7 Primary energy

All processes in our society depend on energy. This energy is derived from different sources. All energy is derived from primary energy sources. For each of the disposal options the primary energy usage is calculated as follows.

Recycling

The recycling process uses between 1,962 MJ PE/tonne (mechanical recycling of rigid PVC) and 10,301 MJ/PE/tonne (Vinyloop for plasticized PVC) [WRAP]. The recycling of PVC waste prevents the usage of primary energy for the production of virgin PVC compound. The prevented primary energy lies between 18,931 MJ PE/tonne recycled rigid PVC waste and 21,747 MJ PE/tonne recycled plasticized PVC waste. The net primary energy use prevention is 16,969 MJ PE/tonne for rigid PVC and 11,446 MJ PE/tonne plasticized PVC. The values in [WRAP] are comparable to the values in [PE Europe] which gives a net primary energy use prevention of 18.422 MJ PE/tonne PVC cable waste recycled in the Vinyloop process. In the calculations we use the values from WRAP as these values differentiate between rigid and plasticized PVC waste.

Incineration

During incineration heat is recovered from the flue gasses of the incinerator. According to [Menke et al.] the heating value of rigid PVC is around 16,000 MJ/tonne and plasticized PVC has a heating value around 20,000 MJ/tonne. At an estimated energy recovery percentage of 36 % [PE Europe] this would result in 5,760 MJ PE /tonne incinerated rigid PVC waste and 7200 MJ PE/tonne incinerated plasticized PVC waste. [PE Europe] calculated that one tonne of cable waste will substitute 8,445 MJ PE, a comparable amount to the values based on the heating value calculated before. As rigid and flexible is more general we will use the primary energy values from these types instead of from cables.

Landfilling

Landfilling consumes a little energy, mostly for the machinery used on the landfill. The primary energy usage per tonne landfilled is 181 MJ PE for profiles and 165 MJ PE for flooring [WRAP]. We have used these values for rigid and plasticized PVC respectively.

Export

We have assumed that exported PVC will be recycled. Therefore the same values are used as given in the subparagraph about recycling. However because the PVC waste has to be transported before recycling we have added the used energy for transport. Energy usage according to [STREAM] is 4.595 MJ/km for an 80.000 GT ship. An 80.000 GT containership can transport 42.157 tonne. Therefore the energy usage is 0.109 MJ/tonne-km. As these kind of ships use bunker oil and bunker oil has undergone little refining we assume that the energy used gives a fair interpretation of the primary energy usage.

A6.8 Raw material consumption

PVC resin is made out of an organic part (carbon and hydrogen, in total 43 %) and an inorganic part (chlorine, 57 %). The carbon and hydrogen part are usually derived from natural gas or crude oil by refining and cracking. The inorganic part comes from sea salt or rock salt.

Plastics Europe has extensive data on her website about the raw material consumption of different plastic resins. However the eco-profile of specific PVC applications is unavailable as this data is outdated. Only for the resin itself are values available for two different production processes. Rigid applications of PVC contain mostly PVC resin and are compounded from suspension PVC. Roofing and cable PVC articles are made out of suspension PVC as well. Flooring is made of emulsion PVC.

Plasticized PVC however can contain large amounts of other components. In some applications as much as 60% additives can be present. As there is not one typical composition for plasticized PVC, typical raw material consumption for plasticized PVC is unavailable. As additives usually are organic components we assume that for the plasticized PVC applications the raw material consumption of 1 tonne compound is comparable to the raw material consumption of half a tonne of PVC resin and half a tonne of Naphtha. Table A6.2 shows the used data for the calculation of the raw material consumption.

Table A6.2 Raw material consumption of rigid and plasticized PVC compound

PVC type	Oil/gas/condensate/coal/lignin (organic)	Sodium Chloride (inorganic)
Profiles and pipes	1.14	0.61
Cable and roofing	1.13	0.31
Flooring	1.30	0.38

The oil consumption for PVC production of a pipe is given in [UGSI] calculates to 1.22 kg/kg of PVC. This value is comparable to the values used in this study.

A6.9 Literature list for appendix 6

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Appendix

7

Calculated lead concentrations in PVC waste and new articles

A7.1 Introduction

The lead concentration has been calculated for PVC waste for the five different applications considered. The concentration in the waste and in new articles made with the recycled PVC waste has been plotted against time. The resulting graphs are given in this appendix. The conclusions that can be drawn from these graphs can be found at the end of this appendix.

A7.2 Lead concentration graphs

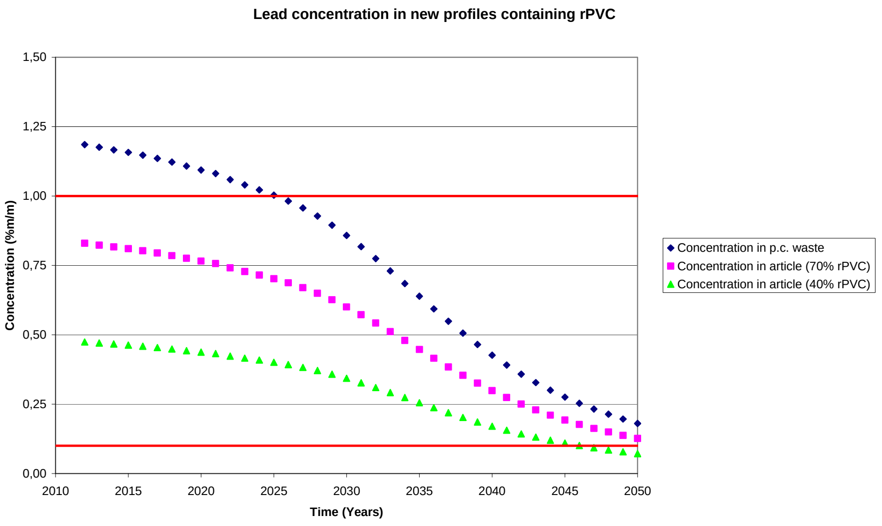

Figure A7.1 Lead concentration in new profiles containing rPVC and lead concentration in PVC profile waste

At this moment approximately 40 % rPVC is used in the production of new window profiles. Graph A7.1 shows that at a recycled content of 40% the current lead concentration is approximately 0.5 % in the new article. The actual measured lead concentrations at this moment are approximately 0.35 % lower than the modelled values [personal communication VEKA]. Therefore in practice a 1 % restriction threshold would be no problem. A 0.1 % restriction threshold would probably result in a collapse of recycling in Europe as this restriction threshold could only be met at a recycled content of approximately 8 %. At that recycled content the extra investment costs needed to process rPVC will be more than the benefit of lower material prices.

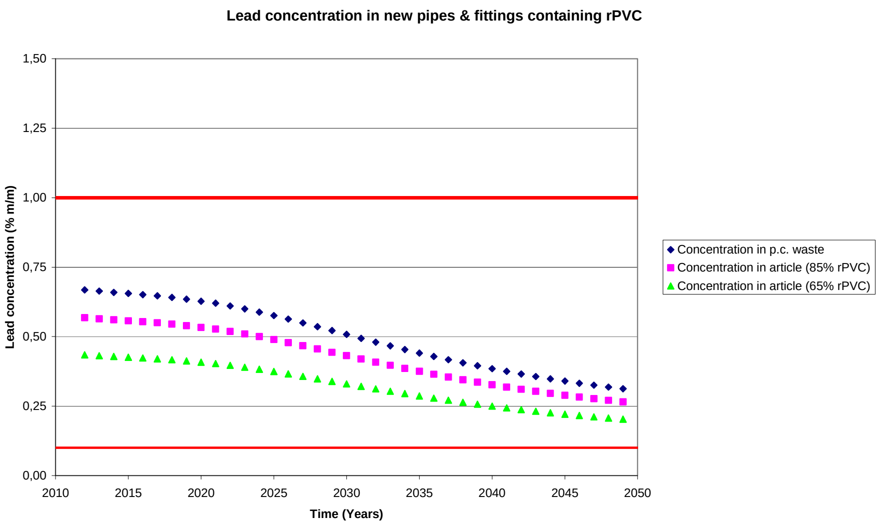

Figure A7.2 Lead concentration in new pipes containing rPVC and lead concentration in PVC piping waste

Lead concentrations in PVC piping waste are approximately 0.7 % therefore recycling of PVC piping waste would pose no problem if a restriction threshold of 1 % would be set. A restriction threshold of 0.1 % would probably result in a collapse of recycling in Europe.

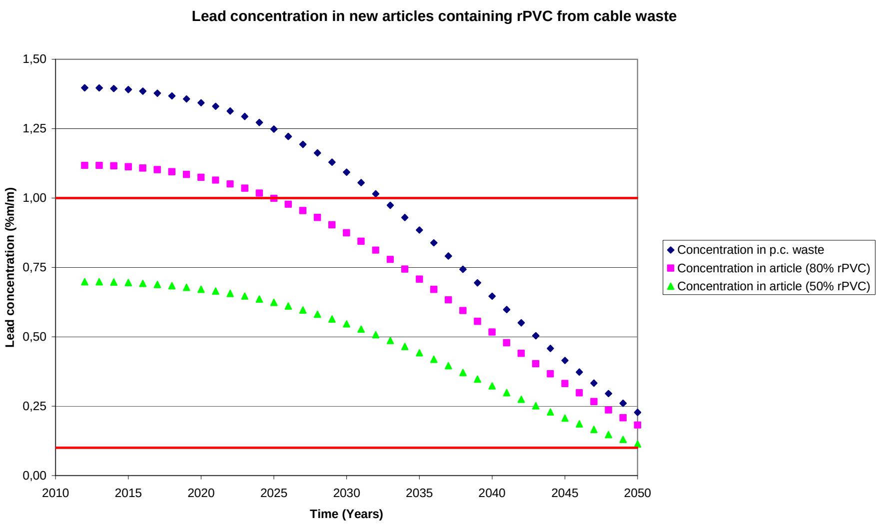

Figure A7.3 Lead concentration in new articles containing rPVC from cable waste and lead concentration in PVC cable waste

The lead content in PVC cable waste is approximately 1.4 % at present. Cable waste is used to make other, non-cable, products with 100 % recycled content. This would not be possible if a 1 % restriction threshold would be implemented. Using approximately 70 % recycled content would allow to comply with the restriction threshold of 1 %. A recycled content this high is assumed to be cost effective. Therefore recycling would continue in Europe at a restriction threshold of 1 %. At a restriction threshold of 0.1 % only approximately 7 % recycled content can be used. This is too low to be cost effective.

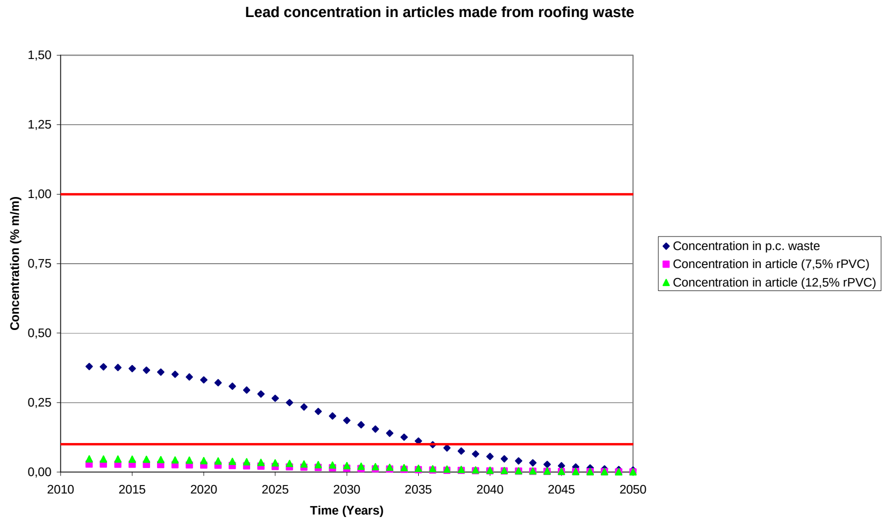

Figure A7.4 Lead concentration in new articles containing rPVC from roofing waste and lead concentration in PVC roofing waste

Lead was used limitedly in the past therefore the lead concentrations in roofing waste are generally low compared to other applications. As the recycled content in new roofing material is generally low due to technical restrictions, the ultimate lead concentration in new roofing material is well below 0.1 %. When rPVC from roofing waste is used in other applications than in roofing material, the recycled content is usually higher. At a restriction threshold of 1 % this poses no problems. At a restriction threshold of 0.1 % this use could be hampered. As the production of new roofing material is large enough to absorb all the available waste we assumed that a restriction at 0.1 % would not hamper recycling.

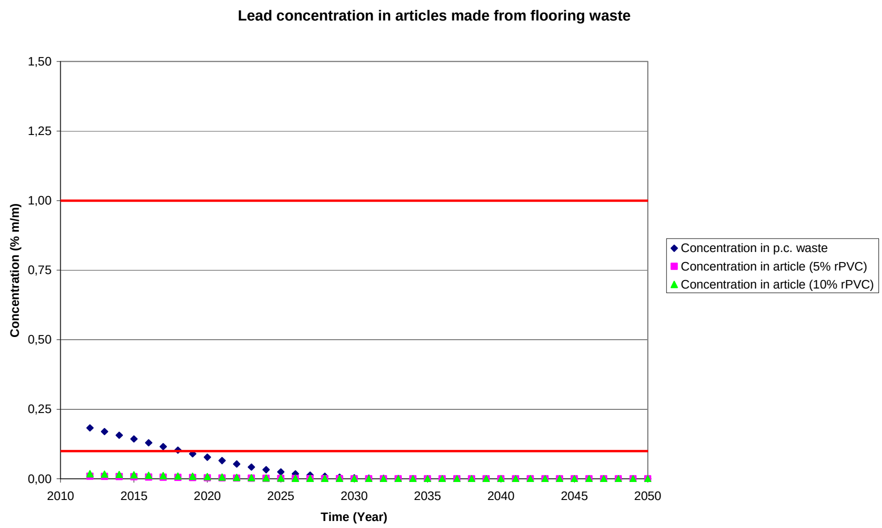

Figure A7.5 Lead concentration in new articles containing rPVC from flooring waste and lead concentration in PVC flooring waste

Lead was used limitedly in the past therefore the lead concentrations in flooring waste are generally low compared to other applications. As the recycled content in new flooring material is generally low due to technical restrictions, the ultimate lead concentration in new flooring material is well below 0.1 %. When rPVC from flooring waste is used in other applications than in flooring material, the recycled content is usually higher. At a restriction threshold of 1% this poses no problems. At a restriction threshold of 0.1 % this use could be hampered, though the recycled content could be in the order of 50 %. As the production of new flooring material is large enough to absorb all the available waste and flooring waste is used in other building products as well, we assumed that a restriction would not hamper recycling. After a few years the lead concentration in flooring waste will have dropped so far that recycling with a restriction threshold of 0.1 % won't be a problem.

A7.3 Conclusions from the lead concentration calculations:

- A restriction threshold of 0.1 % (lowest horizontal red line) would cause a major problem for recycling for profiles, piping and fitting, and cables. In the case of flooring approximately 50% recycled content could be used without exceeding the restriction threshold. Roofing recycling would be possible even at a restriction threshold of 0.1 %
- A restriction threshold of 1.0 % would cause no problem for pipes and fittings, profiles, roofing and flooring. However PVC products made of 100 % rPVC from cable waste will have a lead concentration above 1 % until well after 2030. A recycled content of around 75 % would be possible until 2020. A recycled content of 75 % is assumed to be cost effective and therefore viable. After 2020 the recycled content can be increased progressively to 100 % around 2035

A7.4 Literature list for appendix 7

[Personal communication VEKA] Personal communication with a Veka employee.

Appendix

8

Glossary

Additive: any substance added in small amounts to PVC resin to improve the physical properties of the material in an article

Article: Definition in REACH which has been used throughout this report: means an object which during production is given a special shape, surface or design which determines its function to a greater degree than does its chemical composition

BLL: Blood Lead Level

Blood lead levels: Amount of lead element in the blood of a person, usually expressed in µg/dL

Convertor: Organisation that produces articles out of polymer resin and additives; in the case of PVC the resin and additives are sometimes compounded in a preliminary step

Compound: a mixture of resin and additives

Lead: an element with an atomic weight of 207.2

Lead based stabilizer: a stabilizer that contains the element lead

Lead Compound: any compound that contains lead

Pb: Chemical symbol for lead from the Latin word for lead: Plumbum

Producer: The organisation that makes PVC resin

Recycled material: material that has been a waste and has been collected and treated to obtain a feedstock material for producing new articles

Recyclate: recycled material

Recycled content: the mass percentage of recycled material in an article