SOCIO-ECONOMIC ANALYSIS

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Submitted by:	INEOS Styrenics Netherlands BV *(Lead applicant)*
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Substance:	Hexabromocyclododecane (HBCDD)
Use titles:	Use 1: “Formulation of flame retarded expanded polystyrene (EPS) to solid unexpanded pellets using hexabromocyclododecane as the flame retardant additive (for onward use in building applications).” Use 2: “Manufacture of flame retarded expanded polystyrene (EPS) articles for use in building applications”
Use numbers:	Use 1 and Use 2

CONTENTS

LIST OF ABBREVIATIONS AND ACRONYMS

AoA	Analysis of Alternatives
BFR	Brominated Flame Retardant
BASF	Badische Anilin- und Soda-Fabrik – (A chemical company)
BSEF	Bromine Science and Environment Forum
C&L	Classification & Labelling
CAS	Chemical Abstracts Service
CAT	Category
CBA	Cost-Benefit Analysis
CEFIC	The European Chemical Industry Council
CLP	Classification, Labelling and Packaging
CMAI	Chemical Market Associates, Inc
CO_2	Carbon dioxide – a greenhouse gas
CSR	Chemical Safety Report
DNEL	Derived No Effect Level
DSD	Dangerous Substances Directive (Directive 67/548/EEC)
dw	Dry weight
EBFRIP	European Brominated Flame Retardant Industry Panel
ECB	European Central Bank
ECHA	European Chemicals Agency
EEA	European Economic Area
EFTA	European Free Trade Association
EPM	Equilibrium Partitioning Model
EPS	Expandable Polystyrene
FIW	A research institute for thermal insulation in Germany
EQS	Environmental Quality Standard
eSDS	extended Safety Data Sheet

ESR	Existing Substances Regulation
ETICS	External Insulated Composite Systems
EU	European Union
EUMEPS	European Manufacturers of Expanded Polystyrene
EUSES	European Union System for the Evaluation of Substances
FR	Flame retardant
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GPP	Green Public Procurement
HBCDD	Hexabromocyclododecane
ICF	Insulated Concrete Forms
IR	Infrared
HIPS	High Impact Polystyrene
LCIA	Life Cycle Impact Assessment
LOEC	Lowest Effect Level
LEV	Local Exhaust Ventilation
MS	Member State
MW	Mineral Wool
NOEC	No Observed Effect Concentration
NO_x	Nitrogen oxides – air pollutant from motorised road transport
PAF	Percentage Affected Species
PBT	Persistent, Bioaccumulative, and Toxic
PEC	Predicted Environmental Concentration
PIR	Polyisocyanurate
PM	Particulate matter - air pollutant from motorised road transport
PNEC	Predicted No Effect Concentration
POP	Persistent Organic Pollutants
POP RC	Persistent Organic Pollutants Review Commission

PPE	Personal Protective Equipment
PUR	Polyurethane
RAR	Risk Assessment Report
RCR	Risk Characterisation Ratio
REACH	Registration, Evaluation, Authorisation & restriction of Chemicals
RIVM	Dutch National Institute for Public Health and the Environment
RMM	Risk Management Measure
RoHS	Restriction of Hazardous Substances
SCRAM	Chemical Scoring and Ranking Assessment Model
SEA	Socio Economic Analysis
SEAC	Socio Economic Analysis Committee
SECURE	Self–Enforced Control of Use to Reduce Emissions
SME	Small and Medium Enterprise
SSD	Species Sensitivity Distributions
SVHC	Substance of Very High Concern
TGD	Technical Guidance Document
tpa	Tonnes per annum
UN	United Nations
UNEP	United Nations Environment Programme
VECAP	Voluntary Emission Control Action Plan
ww	Wet weight
XPS	Extruded Polystyrene

EXECUTIVE SUMMARY

A consortium of eight EU Expanded Polystyrene (EPS) formulators are seeking authorisation (through a joint application) for two uses of HBCDD:

1. Use 1: "Formulation of FR EPS to solid unexpanded pellets using HBCDD as the flame retardant additive (for onward use in building applications)"; and

2. Use 2: "Manufacture of FR EPS articles for use in building applications".

EPS is an insulation foam bead (often made into a board) used by the construction sector. HBCDD is used to make the beads fire retardant to meet stringent fire safety requirements and is effective in the final product in low concentrations. This consortium represents over 50% of the EU EPS market.

The applicants are committed to completely switch from HBCDD to an alternative polymeric flame retardant (pFR) as soon as possible over the period 2015-2019. The applicants therefore only seeking a "bridging period" authorisation for continued use with a 4-year review period (i.e. review in 2019). By 2019, there will be certainty over whether it is possible to completely replace HBCDD with a possible polymeric FR (pFR) alternative for uses 1 and 2 in terms of its technical suitability and its availability in sufficient supply.

An authorisation with a 4-year review period would also allow the REACH Regulation, which covers the European Union (EU) region, to align itself with the Stockholm Convention on Persistent Organic Pollutants (POPs) which covers most parts of the world. According to the Sixth Conference of Parties in May 2013 (EC 2013), HBCDD has been recommended to be included on Annex A of the Stockholm Convention on Persistent Organic Pollutants (POPs). This would lead to an international ban on the production, placing on the market and use of HBCDD in, HIPS and textiles as well as non-building-related applications of EPS and XPS.

A bridging authorisation is being requested to continue to use HBCDD in FR EPS by pellet producers for 4 years for the period 2016-2020 to avoid:

- A situation where there is insufficient supply of the polymeric alternative to meet total demand for EPS production (and XPS production);
- An anti-competitive situation within the EPS market whereby some buyers have supply of the polymeric alternative before others;

- A situation where Member States have not approved the use of the polymeric alternative as a flame retardant in EPS that meets stringent fire safety requirements;
- A loss in market share where there has not been sufficient time to establish market confidence in EPS with the polymeric alternative; and
- To avoid limiting production to non FR EPS because this would not be economically viable. It could lead to plant closures and the loss of jobs as non-FR EPS would not be able to meet fire regulations limiting its applications within construction applications.

The industry has been investigating possible alternatives to HBCDD for a long time as determined in the AoA, and has been proactive in trying to minimise risks which can be seen through results in the SECURE programme (see the CSR and AoA for further details). The applicants are therefore seeking time to phase in the polymeric alternative in a timely manner that preserves the market share that EPS has developed over the last 40 years.

Should authorisation be refused, the initial analysis of alternatives (AoA) indicates that there are no suitable alternatives for EPS producers available. Therefore, a refused authorisation is likely to result in significant economic costs to the EU FR EPS supply chain.

This SEA shows that society is worse off if authorisation is refused for uses 1 and 2. This is due to the significant net economic impact of between €750million and €1,175million (in present value terms). This impact outweighs the estimated net environmental benefit of reducing HBCDD of up to 1.98 tonnes into the environment. As it is not possible to put a monetary value of up 1.98 tonnes of HBCDD in the environment, it is worth examining it from a cost per tonne perspective. The net cost of a refused authorisation is estimated at to be between €379million/tonne (=750million/1.98) and €594million/tonne (=1175/1.98) of HBCDD avoided into the environment.

In order to put these costs per tonne into perspective EU average damage costs per tonne emitted for a number of different air pollutants (which is an area where it has been possible to value impacts) range from several euros per tonne (CO_2) to around a million per tonne for substances such as lead, mercury and PAHs. Therefore estimates of between €379million/tonne and €594million/tonne (for HBCDD) are significantly higher making it clear that even if the benefits to the environment were estimated that the benefits of a refused authorisation would not outweigh the costs.

1. INTRODUCTION

1.1. Objective of this Socio Economic Analysis (SEA)

The objective of this SEA is to determine whether the benefits of the applicants continued use of hexabromocyclododecane (hereafter referred to as HBCDD) as a flame retardant (FR) in the formulation and manufacture of expanded polystyrene (EPS) outweigh the risks to human health and the environment.

The two uses of HBCDD that the applicants are seeking authorisation for are:

1. Use 1: "Formulation of flame retarded expanded polystyrene (EPS) to solid unexpanded pellets using hexabromocyclododecane as the flame retardant additive (for onward use in building applications)."

2. Use 2: "Manufacture of flame retarded expanded polystyrene (EPS) articles for use in building applications"

The applicants are seeking a "bridging period" authorisation for continued use with a four year review period (i.e. review in 2019). By 2019, there will be certainty over whether it is possible to replace completely HBCDD with a possible polymeric FR (pFR) alternative for uses 1 and 2 in terms of its suitability and availability in sufficient supply. The SEA is therefore focused on justifying authorisation over a short period of time rather than indefinite use.

An authorisation with a four year review period would allow the REACH Regulation, which covers the European Union (EU) and the European Economic Area (EEA) to align itself with the Stockholm Convention on Persistent Organic Pollutants (POPs) the signatories of which covers most of the world[1]. According to the Sixth Conference of parties in May 2013 (EC 2013)[2], HBCDD has been recommended to be included on Annex A of the Stockholm Convention on Persistent Organic Pollutants (POPs). This would lead to an international ban on the production, placing on the market and use of

[1] Notable non-ratifying states include the United States, Israel, Malaysia, Italy and Iraq - http://chm.pops.int/Countries/StatusofRatifications/tabid/252/Default.aspx

[2] (EC 2013) - Proposal for a COUNCIL DECISION on the position to be adopted, on behalf of the Europe Union, at the Sixth Conference of the Parties to the Stockholm Convention on Persistent Organic Pollutants with regard to the proposal for an amendment of Annexes A and B. Available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2013:0134:FIN:EN:PDF

HBCDD in, High Impact Polystyrene (HIPS) and textiles as well as non-building-related applications of EPS and Extruded Polystyrene (XPS).

Under the Stockholm Convention (also referred to in this report as UNEP) a five-year exemption (for continued use of HBCDD) has been recommended for building applications of EPS and XPS until November 2019. If necessary, this exemption can be extended by another five years depending on the availability of the polymeric FR alternative (pFR) assuming that there is no other legislation had been put in place (such as and authorisation or restriction under the REACH Regulation in the EU).

As stated in the ECHA authorisation guidance[3], in order for the applicants to continue to benefit from a granted authorisation beyond 2019, the applicants must submit a review report at least 18 months before the expiry of the time-limited review period (i.e. by early 2017).

IMPORTANT NOTE FOR THE READER

This report sets out the SEA for both uses 1 and 2. As the analysis contained within these reports will show, authorisation is needed for both uses given how interdependent the two uses are (i.e. there is little benefit to the applicants having authorisation for one use without authorisation for the other use).

The impacts of a refused authorisation for use 1 and use 2 are kept separate within different chapters. However the baseline scenario covers both uses as a good understanding of the whole supply chain is required which can only be done by explaining the two uses within one chapter (and in order to avoid unnecessary duplication of text).

For this SEA report:

- The baseline scenario assumes continued use of HBCDD for use 1 and use 2; and
- The non uses scenarios assume authorisation is refused for use 1 and use 2.

Use of decimal marks in this report

In this report:

- 10,000 refers to ten thousand rather than ten; and
- 100.25 refer to one hundred and a quarter.

[3] ECHA 2011, Guidance on the preparation of an application for authorisation Version 1 January 2011

1.2. Hexabromocyclododecane (HBCDD)

1.2.1 What is HBCDD

HBCDD is a substance that is made of carbon, hydrogen and bromine atoms. There are twelve carbon atoms in a ring formation and six of them have a bromine atom attached. The substance functions effectively as a flame retardant due to the presence of the bromine atoms, which, when the compound decomposes at high temperatures, act to quench the chemical reactions occurring in the flame, reducing the heat generated, and slowing or even, preventing the burning process.

HBCDD can exist in a number of forms called diastereoisomers, which result from the different positions of the six bromine atoms in terms of how they are orientated in space. The main three forms are gamma (γ), beta (β) and alpha (α), the substance is mainly in the gamma form with the alpha and beta as well as some other impurities. The HBCDD supplied to the applicants and the subject of this application is described in the accompanying CSR as a mono-constituent substance (substance 1) and a multi-constituent substance (substance 2). The mono-constituent substance has over 90% of the gamma diastereoisomer and between 1 -4% alpha and 1-7% beta. The multi-constituent substance comprises the three main diastereoisomers (alpha, beta and gamma) plus two minor stereo-isomers (delta and epsilon) considered as impurities, with gamma isomer at between 65% and 85%.

HBCDD is used as a flame retardant in other materials, mainly plastics, more specifically in thermal insulation foams and in textile coatings (BSEF 2009)[4] to inhibit/reduce the spread of fire. HBCDD is a white solid material (at 20°C) with a boiling point of >190°C. It has a low vapour pressure ($6.3 * 10^{-5}$ Pa at 21 °C) suggesting that it is not expected that the substance will be easily released from products into air at room temperature. In addition, the low solubility of the substance in water (65.6 µg l^{-1}) suggests that the concentration in environmental water will be low (ECHA 2009)[5].

[4] (BSEF 2009) – "*Fact sheet Edition June 2009 – HBCDD Hexabromocyclododecane*" by the Bromine Science and Environment Forum (BSEF): http://www.bsef.com/uploads/Documents/documents/HBCDD_factsheet.pdf

[5] (ECHA 2009) "*Annex XV dossier - Proposal for Identification of a substance as a CMR CAT 1 or 2, PBT, vPvB or substance of an equivalent level of concern. Proposal for identification of Hexabromocyclododecane as aSVHC*": http://echa.europa.eu/documents/10162/3f5de199-8732-4881-aec6-730bf9499a36

1.2.2 Uses of HBCDD

HBCDD is solely used as an additive flame retardant in four principal product types (ECHA 2009b[6]):

i. Expandable polystyrene (EPS):

  - An insulation foam bead (often made into a board) used by the construction (building applications) and packaging sector. HBCDD is used to make the beads fire retardant to meet stringent fire safety requirements and is effective in the final product at low concentrations (typically less than 1%).

ii. Extruded polystyrene (XPS):

  - An insulation foam bead (often made into a board) used by the construction and packaging sector. HBCDD is used to make the beads fire retardant to meet stringent fire safety requirements and is effective in the final product in low concentrations (0.5-3%).

iii. High impact polystyrene (HIPS)

  - A minor use in electrical and electronic equipment. HBCDD is found in the final product in low concentrations (1-3%).

iv. Polymer dispersion for textiles

  - A textile coating agent applied mainly in upholstery fabric. Again HBCDD is used to make the textile fire retardant to meet stringent fire safety requirements and can be found in the product in higher concentrations (25% or 6-15% in final layer).

The applicants are only seeking the continued use of HBCDD for EPS only (i) and specifically for use in building applications[7] . Therefore, other uses of EPS (i.e. packaging) and other uses of HBCDD (ii,iii,iv) are not considered further.

[6] (ECHA 2009b) – "*Data on the manufacture, import, uses and releases of HBCDD as well as information on potential alternatives to its use*" http://chm.pops.int/Portals/0/download.aspx?d=UNEP-POPS-POPRC.5-REL-HBCDD-ECHA_TechReport.pdf

1.2.3 Status under REACH

Under REACH, HBCDD was identified as a Substance of Very High Concern (SVHC) meeting the criteria of a PBT substance pursuant to Article 57(d). It was therefore included in the candidate list for authorisation following ECHA's decision ED/67/2008 on 28 October 2008[8].

HBCDD was prioritised for authorisation by ECHA due to the wide dispersive uses of end products containing HBCDD, and the high volumes and potential releases over the full life-cycle of articles and preparations.

HBCDD[9], has been placed on Annex XIV of the REACH regulation. Consequently a granted authorisation is required for continued use of the substance beyond the sunset date of 21/08/2015. For an authorisation application to be assessed by ECHA an application for authorisation must be submitted to ECHA before 21/02/2014 (i.e. 18 months in advance of the sunset date).

The following information on EPS is provided for a better understanding of this study:

1) EPS 'beads' *before* expansion are considered to be a mixture and thus within the scope of authorisation. Therefore, for differentiation and clarity in this study they are referred to as 'pellets'.

2) The expanded beads and beads made into boards are understood to be articles under REACH[10].

The process of Authorisation is relevant to the use of HBCDD to make unexpanded EPS beads within the EU and EEA ("Use 1") and the use of those unexpanded beads to make expanded beads and boards in the EU and EEA ("Use 2").

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[7] Note building applications includes mostly thermal insulation, but also acoustic and seismic insulation uses and some decorative building applications which are not insulation uses. It covers all internal and external applications, attached to and separate from a building, but integral to construction of a building.

[8] (ECHA 2009c) - Background document for hexabromocyclododecane and all major diastereoisomers identified (HBCDD) http://echa.europa.eu/documents/10162/9b8562be-30e9-4017-981b-1976fc1b8b56

[9] Covering the major diastereo isomers alpha-hexabromocyclododecane, beta-hexabromocyclododecane and gamma-hexabromocyclododecane (CAS numbers 3194-55-6, 25637-99-4, 134237-50-6, 134237-51-7 and 134237-52-8 and EC numbers 221-695-9 and 247-148-4).

[10] For a full explanation of what is and what is not an article the ECHA Guidance on substances in Articles should be consulted.

It is understood that authorisation does not apply to the import into the EU/EEA of articles and therefore beyond the sunset date articles containing HBCDD could continue to be imported, as long as the obligations set out under Article 33 of REACH are met.

1.2.4 Hazard classification

Substances are classified and labelled according to their properties in terms of toxicity and their physical and chemical properties. The system for application of hazard classification and the appropriate labelling to apply to substances in the EU is Classification & Labelling in accordance with the CLP Regulation (Regulation (EC) 1272/2008) – CLP. In addition, the previous system for classification and labelling in the EU, the Dangerous Substances Directive (Directive 67/548/EEC) - DSD, is still used (for example in REACH registration dossiers and extended safety data sheets where both classification systems are required).

The classification and labelling system can be applied by manufactures and suppliers of the substance placing the substance on the EU market, proposing classification and labelling under CLP and DSD, so called self-classification. The classification can be 'harmonised' which means that the classification and labelling has been agreed at EU level (by the European Commission in consultation with Member States) and this then becomes the official classification and labelling in the EU.

For HBCDD some aspects of the classification of the substance have been agreed (such as the classification for danger to the environment) and harmonised (such as the reproductive toxicity). What is set out below is only the classification and labelling that has been agreed and/or harmonised; self-classification proposals are not shown.

Under the Dangerous Substances Directive (Directive 67/548/EEC), HBCDD is classified as dangerous to the environment; R50-53 ('Very toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment') as agreed at a Technical Committee for Classification & Labelling (TC C&L)-meeting on 11-12 June, 2003. The environmental classification for the substance has not been harmonised.

At the time of the EU Risk Assessment Report (RAR), HBCDD was not yet classified for hazards to human health. However, the Committee for Risk Assessment – RAC Opinion, proposing harmonised classification and labelling at Community level of hexabromocyclododecane (HBCDD) (ECHA/RAC/CLH-O-0000001050-94-03/F) Adopted 8 December 2010, concluded that HBCDD should be classified for hazard to human health on the basis of reproductive toxicity and danger to breast fed children. The Dangerous Substances Directive and CLP classifications of HBCDD are presented below:

Classification & Labelling in accordance with the CLP Regulation (Regulation (EC) 1272/2008)	
Classification	Repr. 2 - H361 (Suspected of damaging fertility or the unborn child.) Lact H362 (May cause harm to breast-fed children)
Specific concentration limits	none
Labelling	GHS08, Wng, H361, H362
Classification & labelling in accordance with Directive 67/548/EEC	
Classification	Repr. Cat 3; R63 (Possible risk of harm to the unborn child) R64 (May cause harm to breastfed babies)
Specific concentration limits	none
Labelling	Xn; R 63 - 64; S36/37-53

The classification for reproductive toxicity for HBCDD would also meet the toxicity “T” criterion for PBT; however the T criterion is already met for aquatic toxicity.. Although the focus of the study should be on the properties of the substance that cause it to be listed on Annex XIV, i.e. PBT (with T met in this case by aquatic toxicity), the potential impacts on human health through environmental exposure (i.e. not in the workplace) in the SEA assessment cannot be disregarded and is included within this assessment.

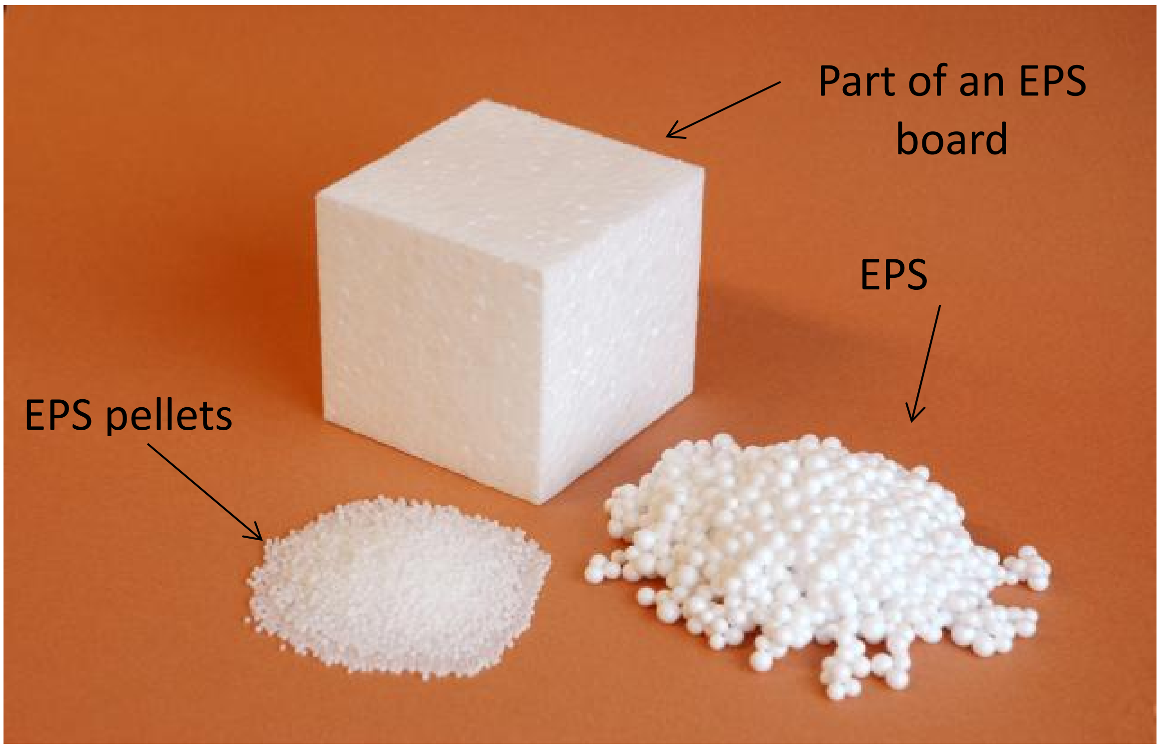
1.3. Expanded Polystyrene (EPS)

1.3.1 What is EPS?

As set out by the European Manufacturers of Expanded Polystyrene (EUMEPS), EPS “is a lightweight, rigid, plastic foam insulation material produced from solid beads [pellets] of polystyrene. Expansion is achieved by virtue of small amounts of pentane gas dissolved into the polystyrene base material during production. The gas expands under the action of heat, applied as steam, to form perfectly closed cells of EPS. These cells occupy approximately 40 times the volume of the original polystyrene bead. The expended EPS beads are then moulded into appropriate forms suited to their application" [11].

Figure 1.1 illustrates the various stages from PS beads (also referred to as EPS 'pellets' in this study) which are then 'blown/expanded' to make EPS beads (which can be used as a final product). These beads are then more commonly formulated into final products such as EPS boards for insulation in construction applications and moulds for packaging of valuable goods.

Figure 1.1 EPS material structure



Source: EUEMPS[12]

1.3.2 Building applications of EPS

According to EUMEPS, EPS has been in use for the past 40 years. The EPS industry holds a market share of 35% of the total insulation market for construction in Europe.

[11] European Manufacturers of Expanded Polystyrene (EUMEPS) - http://www.eumeps.org/eps_4105.html?psid=48b0867885827f241ef221fd4693fc2d

[12] EUMEPS website: EPS material structure http://www.eumeps.org/applications_4536.html?psid=48b0867885827f241ef221fd4693fc2d

The properties of EPS insulation materials for buildings and their test methods are defined in EN 13163, which has been mandatory since 13 May 2003 for all EU countries. EN 14933 is the relevant standard for civil engineering applications. These harmonised European standards include a list of properties (e.g. thermal conductivity, dimensional stability and compressive and bending strength) and test methods both for general and for specific applications of EPS.

Uses of EPS can be broadly categorised into two main groups: building applications and packaging, with most (>85%)[13] flame retarded (FR) EPS (i.e. containing HBCDD) being used for building applications. A list of building applications is presented below (and also depicted on the EUMEP website[12]):

- Flat roof insulation;
- Pitched roof insulation;
- Floor insulation ‘slab-on-ground’ insulation;
- Insulated concrete floor systems;
- Interior wall insulation with gypsum board (doublage);
- Exterior wall insulation or ETICS (External Insulated Composite Systems);
- Cavity wall insulation boards;
- Cavity wall insulation loose fill;
- Civil engineering applications;
- Insulated concrete forms (ICF);
- Foundation systems and other void forming systems;
- Load bearing foundation applications;
- Core material for EPS used in sandwich and stressed skin panels (metal and wood fibreboard);
- Floor heating systems;
- Sound insulation in floating floors (to avoid transmission of contact sound);
- Seismic applications; and
- EPS drainage boards.

1.4. SEA method

This SEA has under gone a number of iterations prior to completion. A scoping study was developed and included to ECHA as part of the pre submission information (PSIS). Following the scoping study a number of the SEA chapters were drafted and reviewed by

[13] Based on questionnaire responses from consortium EPS producers on end uses of FR EPS (See Appendix C)

the consortium prior to producing a fully drafted SEA. The drafted SEA underwent further refinement through discussions with all consortium members, especially because more information became publicly available after October 2013 e.g. following developments at the UNEP meetings.

A number of sources of information where used with the main sources of data coming from data provided by consortium members (e.g. through questionnaires) and documents made available via Plastics Europe. This includes information relating to production and sales processes, historical quantities and market forecasts. It covers the European market, supply chains, alternatives and other important information for insulation market. Wherever possible desk-based research was carried out in order to verify any information provided.

Impacts within the EU were assessed by determining the most likely responses along the supply chain in response to a refused authorisation. This was based on consortium responses but also stakeholder engagement with the downstream supply chain. The net impacts are assessed by comparing the likely impacts from a refused authorisation to the baseline scenario. Impacts are assessed from a 'societal perspective' in accordance with ECHA SEA guidance.

In order to undertake a CBA all significant impacts were determined and assessed (at some level; qualitative, quantitative or monetary). There were several impacts that worth noting but not significant enough to warrant assessing in detail (i.e. some impacts will have little bearing on determining whether benefits outweigh costs).

Where monetisation of impacts was possible, the results will be presented in net present value (NPV) using a 4% discount rate as recommended in the ECHA SEA guidance. The final comparison of costs and benefits is set up in a cost benefit analysis (CBA) framework but not all benefits and costs are quantified and monetised (e.g. where it is not proportionate to do so or due to limitations in data available). Therefore any key non-monetised impacts should not necessarily be given less weight and should be considered alongside monetised impacts wherever possible.

1.5. The applicants: The EPS consortium

This joint application for authorisation is being submitted for continued use of HBCDD for the formulation and manufacture of FR EPS for building applications. The application is intended to cover the following EPS producers shown in Table 1.1 (in alphabetical order).

Table 1.1 Applicants

EPS consortium member	No: of plants in the EU	Location of plants
Ineos Styrenics	3	Netherlands, France x 2
Ravago: Monotez SA and RP Compounds GmbH	2	Greece, Germany
StyroChem Finland Oy	1	Finland
Sunpor	1	Austria
Synbra	1	Netherlands
Synthos Group	2	Czech Republic, Poland
Unipol	1	Netherlands
Versalis SA (eni)	2	Italy, Hungary
TOTAL	**13**	**-**

As authorisation is required by EU manufacturers of EPS (i.e. using EPS pellets) under Use 2, this authorisation application covers customers of the applicants above.

The next section (Section 2) presents the baseline scenario which assumes the continued use (but phased out) of HBCDD for use 1 and use 2.

2. BASELINE SCENARIO – SHORT TERM USE OF HBCDD IN EPS

2.1. Short term: Continued use of HBCDD in EPS (2015-2019)

This section sets out the scenario where authorisation to continue to use HBCDD for uses 1 and 2 for FR EPS in building applications is granted with a four year review period. Within four years (i.e. between 2015 and 2019) the applicants are committed to substituting away from HBCDD to the polymeric flame retardant (pFR). A number of technical steps need to happen (i.e. complete a product testing programme with commercial grade pFR, ensure customer acceptability and ensuring compliance with relevant safety standards) as well as secure availability of the pFR.

Authorisation is being sought for continued use of HBCDD with a review period after four years (i.e. 21 August 2019) for the use of HBCDD in making EPS for building applications (Uses 1 and 2). This extended time period is required as there are uncertainties/concerns that the proposed pFR alternative may not be readily available in sufficient supply after the sunset date to meet the demands of both EPS and XPS producers. During the proposed authorisation period (2015-2019), it is expected that the use of HBCDD for EPS use would progressively decline and ultimately be totally replaced by the pFR alternative.

Currently, trials have been undertaken by all EPS producers in small quantities based on samples provided by pFR producers which indicate that the pFR will be technically feasible. It is known that the pFR will cost more than HBCDD on a weight for weight basis but it is assumed to be economically feasible as EPS producers have the intention to switch from HBCDD to the pFR (although no price data has been provided for the pFR). Further tests will be required on the commercial supply of the pFR[14] (further details are available in the Analysis of Alternatives - AoA). Testing and confirmation of technical suitability of a new FR will need to be carried out, both by the pellet and article producer.

[14] A product sample available during a trial is often not the same as the final product which is mass produced ("commercially available"). The manufacturer will often change the formulation/ingredient mix to maximise revenue and also reflect any changes necessary in the production process when produced in larger quantities. For example, it is known that the suppler Chemtura has changed their product from a powder to a compacted powder which has different loading requirements and potentially different handling requirements and/or equipment. It is yet to be known what form the other producers will supply. Testing and iterations all take time and the final testing has to be done on the full scale reactors fitting in between regular production for a commercial business.

Further marketing also needs to be done with end users to establish awareness of a new product. Further tests on the pFR itself may also be required for Member States to give certified approval of its use as a flame retardant[15].

The Dow Chemical Company owns the patent to the pFR and has granted licences to three producers of HBCDD[16]. The pFR was initially designed as a replacement for HBCDD in XPS use but can also be used for making EPS (albeit with more pFR is needed relative to HBCDD to achieve given fire retardant requirements). Manufacturers seem to be committed to making the polymeric alternative but uncertainties exist as to how many production sites will be built on time and fully operational by the sunset date to meet global demand[17] for EPS and XPS use. For any pFR supply available, XPS manufacturers and some FR EPS producers not part of the consortium are thought to have secure contracts in place for the initial supplies that will be available. Further details are set out in Section 2.3.

EPS consortium producers (the ‘applicants’) are therefore seeking authorisation to continue to use HBCDD to make FR EPS until there is sufficient supply of the polymeric FR alternative which meets EPS customer requirements and required certification. Table 2.1 summarises the justification for a continued use of HBCDD in EPS in the short term.

[15] Testing is currently being carried out by FIW on behalf of IVH and the results are being discussed with the German authorities to allow a generic approval of the pFR as a replacement to HBCDD.

[16] The Dow Chemical Company owns the Intellectual Property and have licenced this to the other producers; http://www.dow.com/licensing/news/2011/20110329a.htm

[17] It is important to note that despite announced production dates before the sunset date, the commercial product when available, will still need to be tested and confirmed suitable by the EPS pellet producers and the downstream (see also footnote number 14 above).

Table 2.1 Justification for short-term use of HBCDD in EPS

No:	Rational for additional time to use HBCDD
1	To avoid a situation where there is insufficient supply of commercially qualified polymeric alternative to meet total demand for FR EPS production.
2	To avoid an anti-competitive situation within the EPS market in which some buyers have supply of the polymeric alternative before others do.
3	To avoid a situation in which Member States have not approved the use of the polymeric alternative as a flame retardant in EPS that meets stringent fire safety requirements.
4	To avoid a loss in market share due to a lack of sufficient time to establish market confidence in EPS made using the polymeric alternative.
5	To avoid limiting production to non-FR EPS because this would not be economically viable and would lead to plant closures and the loss of jobs. This is because non-FR EPS would not be able to meet fire regulations which would limit its applications within building use applications.

2.2. Long term: Use of a polymeric FR alternative to HBCDD (post 2019)

In effect, what is being proposed is an extended sunset date (21 August 2019), whereby the situation is reviewed in four years' time. The intention of the EPS consortium producers is to completely phase out their use of HBCDD, when the pFR is available in sufficient supply and meets all technical requirements and certifications. It is believed that this switch away from HBCDD can occur by 2019, but is dependent on sufficient supply of the pFR.

Again, as stated in the ECHA authorisation guidance (2011), in order to continue to benefit from an authorisation beyond 2019 (if successful with their application) the applicants must then submit a review report at least 18 months before the expiry of the time-limited review period (i.e. by early 2017).

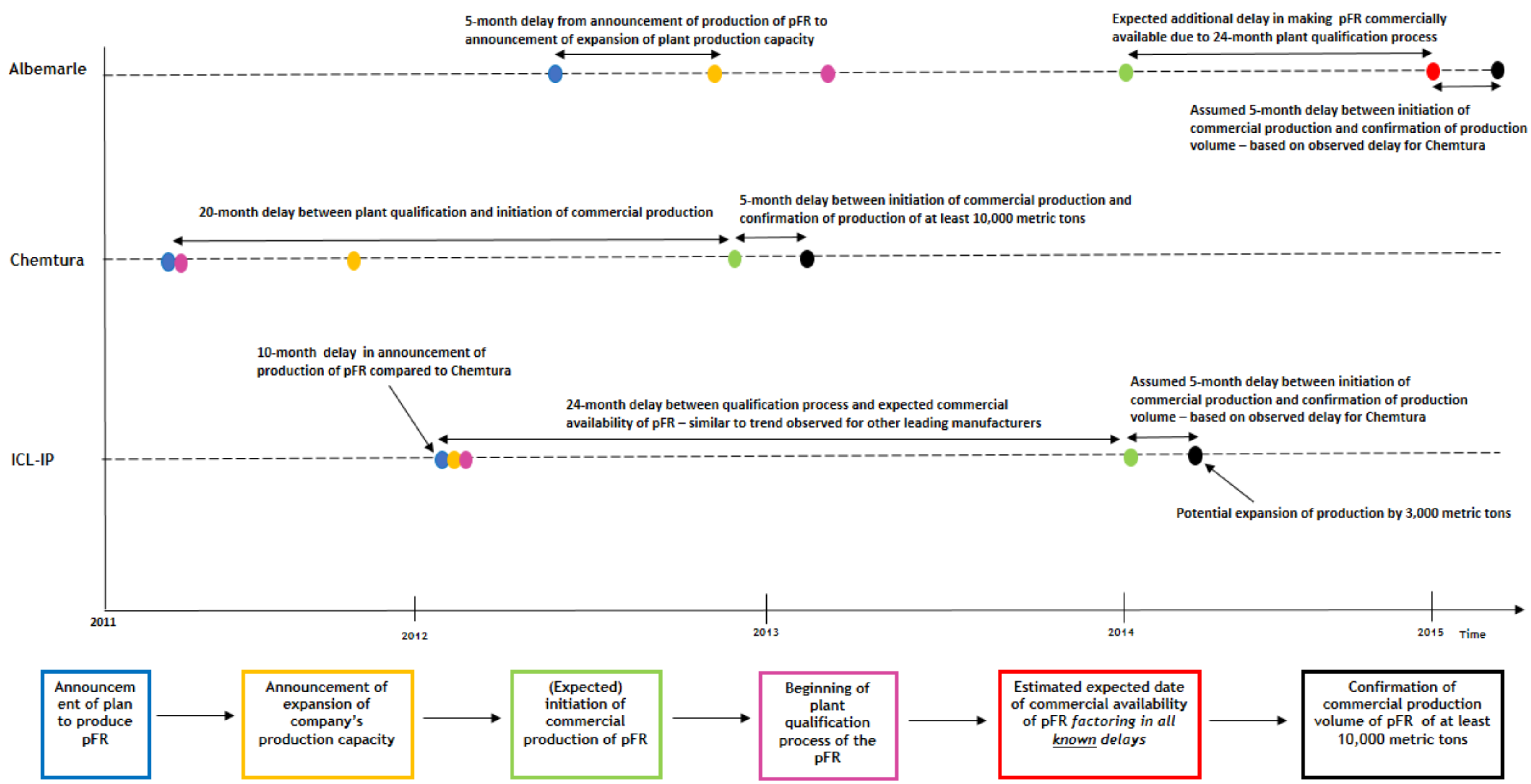
2.3. Supply and demand of the pFR alternative

2.3.1 Supply of the pFR

Based on a search of press releases[18] on the production of the pFR (see Appendix B) there are three known manufacturers of the pFR in the world, namely Albemarle, Chemtura and ICL-IP. Figure 2.1 illustrates a timeline with a trajectory towards making the pFR commercially available for each of the three manufacturers of the pFR.

[18] It is accepted that press releases are effectively marketing documents but provide the only source of publicly available information on expected supply of the pFR. It could also create more important queries and concerns on the application were they ignored.

Figure 2.1 Timeline for estimating commercial supply of the pFR



If the press releases are to be believed, then, by mid-2015, all known commercial supply of the pFR will be available. However, it is important to note that further time will be required for EPS formulators to test the new pFR and further refinements of the pFR or the production process, are expected before FR EPS can be formulated.

Based on the press releases (which are mostly comprised of marketing information) in mid-2015:

- Albemarle is understood to have just opened its pFR production site with a 'nameplate capacity' (see definition below) of 10kt per year. At best, its nameplate capacity for 2015 will be around 5kt per year (i.e. half a year's production). Its actual capacity will be much lower than 5kt as they will still need to optimise their production process and send samples to EPS producers to test. At the time of finalising this SEA (December2013), no building construction had started for this site yet;
- Chemtura is predicted have a nameplate capacity of 10kt from its pFR production site which is already operational; and
- ICL-IP is predicted to have an actual output of ~ 10kt per year from its two pFR sites (total nameplate of 13kt per year). One of these sites is already operational (~2-3kt nameplate capacity which is assumed to be 3kt for modelling purposes) and the other site expected to be operational by mid-2014 with its nameplate capacity thought to be 10kt per year.

Based on industry experience from within the consortium, it is important to note there is a difference between nameplate capacities ('productive capacity') which is theoretically what a plant can produce and how much is actually produced (output). 'Product utilisation' (also sometimes called 'capacity utilisation') is measured in percentage terms provides an indication of how close actual output can reach nameplate capacity. Optimistic figures have been used for product utilisation in order to avoid the appearance of bias:

- **30% - Year 1 –** In the first year of operation, it is estimated that actual pFR production will be at best 30% of nameplate capacity (or 15% if operating for only half a year). Time will be required to test the production process at full batch load in order to understand how the process can be optimised so as to minimise operating costs. The products produced will then need to be tested by customers and resulting feedback may result in modifications to the pFR in order to meet EPS requirements;
- **80% - Year 2 –** In the second year the production process will be operating closer to nameplate capacity with a greater understanding of how the pFR can be made to meet customer requirements; and
- **95% - Year 3 onwards –** Finding improvements to go from 80-85% to 90% of nameplate capacity is considered to be much harder. However, from year 3 onwards, it is assumed (optimistically) that pFR producers can operate at a higher proportion of nameplate capacity, equivalent to 95% of nameplate capacity.

Table 2.2 sets out how these utilisation rates were applied to the supply of the pFR from the three manufacturers based on when their plants are expected to be operational.

Table 2.2 Estimated plant pFR production utilisation rates for 2015-2019

	2015	2016	2017	2018	2019
Albemarle	15%	80%	95%	95%	95%
Chemtura	95%	95%	95%	95%	95%
ICL-IP site 1	95%	95%	95%	95%	95%
ICL-IP site 2	80%	95%	95%	95%	95%

Notes:

1. Based on industry expert judgement using optimistic figures. In practice, actual pFR production could be significantly less.
2. Albemarle production utilisation in 2015 is assumed to be 15% rather than 30% reflecting that the plant only opens in mid-2015 (half a year's worth of production time available).

Using the utilisation rates in Table 2.2 and nameplate capacity data from press releases, Table 2.3 shows the expected global supply of the pFR over the period 2015-2019.

Table 2.3 Estimated EU supply of pFR for 2015-2019 (tonnes)

Global supply of pFR	2015	2016	2017	2018	2019
Albemarle	3,000	8,000	9,500	9,500	9,500
Chemtura	9,500	9,500	9,500	9,500	9,500
ICL-IP	10,850	12,350	12,350	12,350	12,350
Total volume	**23,350**	**29,850**	**31,350**	**31,350**	**31,350**

Notes:

1. Based on nameplate capacity in press releases (See Appendix B) and utilisation rates in Table 2.3

The uncertainty of regulatory outcomes (e.g. countries potentially opting out of the UNEP global ban on use of HBCDD) means that pFR suppliers are likely to be reluctant to increase production capacity beyond 33,000 tonnes per year (nameplate) whilst their customers can still use HBCDD. This uncertainty is further compounded by the fact that XPS producers (not EPS) could potentially use other substances than the pFR such as GC SAM[19] in the future (See AoA for further details).

It would not be in the interests of pFR suppliers to have sub-optimal production of both the pFR and HBCDD. It is possible that suppliers will only increase pFR supply when it is clear that their customers are not able to use HBCDD (e.g. from a different supplier). Consortium members, however, cannot guarantee that they will have sufficient commercial supply of the pFR, due to the uncertainty in timing of new start-up productions and the time to technically qualify and certify products their specific pFR, and hence the need for a "bridging" authorisation period [20].

2.3.2 Demand for the pFR

It is expected that the entire volume of the pFR produced will be used in the production of EPS and XPS. This is evident from the review of marketing material (i.e. press releases shown in Appendix B) of all three manufacturers of the pFR in which it is marketed strictly as a substitute for HBCDD in the production of EPS and XPS. Therefore, estimating demand for HBCDD in EPS and XPS provides a good proxy for demand for the pFR.

According to the ECHA report on manufacture, import, export, uses (2009)[6], the volume of HBCDD used by the EU 27 for:

- FR EPS was 3,452 tonnes in 2002 rising to 5,652 tonnes in 2007; and
- FR XPS was 3,954 tonnes in 2002 rising to 5,859 tonnes in 2006.

Over the period 2002 to 2007, the ECHA data shows that demand for HBCDD has increased on average by 10% per year. Based on confidential data provided by consortium members for this application (see questionnaire in Appendix C), increased demand for HBCDD for use in EPS has continued, by ~11.63% per year over the period 2007-2011. Demand for XPS and EPS is estimated to further increase even post-2020 due to policy drivers (e.g. - European Energy Performance of Buildings Directive (EPBD) mandates energy performance certification for new, existing and renovated buildings) to make buildings more energy efficient (See section 2.5.2).

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[19] Presentation by Greenchemicals to Ninth meeting of the Persistent Organic Pollutants Review Committee (POPRC 9) - Rome, Italy, from 14 to 18 October 2013. Meeting documents available at: http://chm.pops.int/TheConvention/POPsReviewCommittee/Meetings/POPRC9/Overview/tabid/3280/mctl/ViewDetails/EventModID/871/EventID/407/xmid/10326/Default.aspx

[20] In economic theory, this is an example of a prisoner's dilemma. The optimal scenario would be that production of the pFR be increased to ensure sufficient supply for EPS and XPS producers. However suppliers will not be willing to invest in plants until they are sure their customers cannot use HBCDD. Therefore downstream users need to be secure of their existence with an authorisation application until it is clear that there will be sufficient commercial (e.g. meets end user requirements) supply of the pFR for all.

As a result of the recession in the EU economy, which has particularly affected the building industry (and in turn the demand of building insulation materials such as EPS and XPS), consortium members have indicated there has been little to no growth in FR EPS sales for the period 2012-2013 and this is expected to be the case for 2014 (0-1% growth). From 2015-2019 post-recession FR EPS sales are predicted to increase year on year by 3% growth rising to 7% growth in 2019/20 due to EU building energy efficiency targets for 2020 and beyond[21].

A confidential CMAI study conducted for CEFIC - EBFRIP (CMAI, 2009[22]) provides the most accurate and detailed EU market data available on EPS and XPS[23]. The study estimates that, 1,461 kt of EPS and 313kt of XPS were produced in 2007. This equates to 6.1kt of HBCDD used for FR EPS and 6.49kt for XPS or 12.63kt in total (for the EU). The detailed calculations are shown in Table 2.4 below.

Table 2.4 Demand for HBCDD in the EU (2007)

	Volume produced in 2007 (kilo tonnes)	Amount used in construction applications (%)	Amount that is FR (%)	Average HBCDD content (%)	Total HBCDD consumed (t)
EPS	1,461	78%	77%	0.7%	6,138
XPS	313	94%	98%	2.25%	6,488
Total	**-**	**-**	**-**	**-**	**12,625**

Notes:

1. Source: CMAI (2009) confidential study
2. Total HBCDD consumed for EPS is calculated as follows: 1,461*78%*77%*0.7%=6,138
3. The ECHA study estimates are from responses by EBFRIP who commissioned this study. The tonnage data in the ECHA (2009) study is slightly lower but this is considered a more robust basis for calculating HBCDD consumption.

Assuming a 4% annual EU growth rate of EPS and 3% for XPS production (based on consortium best estimates) for the period 2007-2011, in 2011 total EU demand for HBCDD is estimated at 14.48kt (7.18kt from EPS and 7.30kt from XPS). This is aligned with estimates provided from collated feedback from several HBCDD producers (who estimate EU demand to be around ~14kt in 2011). The EU estimate is then supplemented by a Chemtura (2013)[24]

[21] In order to provide comparative data, over the period 2008-2012 consortium members increased FR EPS (building applications only) production between 2% and 8% per; average 4.5% over the period.

[22] (CMAI 2009) – "*Review of the Flame-Retardant EPS and XPS Industry in the Enlarged EU*" – A final presentation report prepared for CEFIC – EBFRIP. Updated report: March 2009. Confidential Report.

[23] CMAI is a chemicals market research company. The volume and completeness of data in this report is not matched by any other known source of data. It therefore is the best source of data available for developing the baseline scenario data.

[24] Chemtura (2013) – "*Emerald Innovation 3000 - Polymeric flame retardant for polystyrene foams*". By Marshall Moore, Director Global R&D & Advocacy HBCD Alternatives Information Session - UNEP POPRC9

presentation which provides data on demand for HBCDD from outside the EU (demand in 2011 being ~18.6kt). This is set out in Table 2.5.

Table 2.5 Global demand for HBCDD (2011)

Region	Total HBCDD (tonnes)	Relative share of demand (%)
Japan	2,480	7%
Americas	2,480	7%
Europe	14,483	44%
China	12,090	37%
Korea	1,550	5%
Total	**33,595**	**100%**

Notes:

1. Source: Chemtura (2013) presentation for non-EU demand for HBCDD
2. EU estimate based on CMAI (2009) study data and growth rate of 4%p.a. for EPS and 3%p.a. for XPS

A simple comparison, between the global demand of HBCDD (~33.6kt) and the expected supply of the pFR (31kt at its peak) shows there is a shortage in pFR supply. On the one hand, the expected shortage is an underestimate in that it ignores any adjustment for the fact that more pFR is needed per unit of EPS compared to HBCDD to ensure necessary fire retardant performance. The shortage also excludes any growth in the market for EPS and XPS since 2011. On the other hand, the shortage is an overestimate in that it ignores the fact that some non-EU EPS producers may not need to switch from HBCDD and that *potentially* some XPS producers can switch to another substance (other than the pFR).

In order to provide a realistic estimate of demand of the pFR over the authorisation review period (2016-2019), a spreadsheet model was developed factoring in a number of assumptions/variables. The large number of variables used highlights the complexity and the interdependency of the various factors and highlights that there is significant business uncertainty and concern over the demand and supply of the pFR.

The model used to estimate the volume of the pFR demanded over the authorisation review period proceeds as follows: As a starting point, the first step is to determine on a global scale, which regions are likely to switch away from HBCDD and when. Based on communications with Chemtura[25], it is understood that Japan has partially switched to the pFR, although not

October 14, 2013. Meeting documents available at: http://chm.pops.int/TheConvention/POPsReviewCommittee/Meetings/POPRC9/Overview/tabid/3280/mctl/ViewDetails/EventModID/871/EventID/407/xmid/10326/Default.aspx

[25] Personnel communications on the 04th October 2013

all producers have made the transition as some will switch to Pyroguard SR-130 which is/was not commercially available in the EU[26].

Flint Hills, one of the larger producers of EPS in North America, announced in July 2013[27] that they were in the process of switching from HBCDD to the pFR. Similarly, based on regulatory pressure, it is thought that Canada will also switch to the pFR by the end of the UNEP exemption period in 2019. It is possible that not all Canadian EPS producers will switch to the pFR (e.g. some sites may operate using a two-step process[28]).

It is assumed that Korea will fully switch away from HBCDD by 2015[29]. Based on UNEP discussions it is assumed that China may opt out of the UNEP proposal with companies continuing to use HBCDD post-2019. This is subject to significant uncertainty and therefore it is assumed that 50% of companies in China may in fact switch away from using HBCDD in 2019 (e.g. if there is significant consumer demand to do so). Table 2.6 presents the assumed proportion of companies that are expected to continue to use HBCDD within the concerned regions between 2015 and 2019.

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[26] Pyroguard SR130 (Benzene, 1,1'-(1-methylethylidene)bis[3,5-dibromo-4-(2,3-dibromo -2-methylpropoxy)] from Daiichi has been covered in the AoA. The substance is understood to be used in Japan as an alternative to HBCDD. This substances was not made available commercially to European EPS producers despite the offered of the EPS industry (via Plastics Europe) to work with the Japanese Producers Daiichi to develop the product: Plastics Europe has stated that “SR130 has been tested by EPS Alternative group .It is seen as an insurance policy in case there is any difficulty on the polymeric alternative side. EPS MC did approve the proposal to undertake the Bio accumulation test on the Daiichi material. This is the most critical step along the Reach registration of the product. Daiichi thanked us for our interest but did not want to send a sample for now.” – Plastics Europe January 2012. Like all alternatives in the AoA, relative to the pFR, this alternative is significantly further behind in terms of product testing and qualification amongst EU EPS producers (who have all invested their effort in making the pFR technically feasible). This alternative is therefore even further behind (timing wise) from being technically feasible.

[27] Flint Hill Resources – Press release – “Flint Hills Resources will manufacture expandable polystyrene with new flame retardant technology”. Available at: http://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CEIQFjAA&url=http%3A%2F%2Fchm.pops.int%2FPortals%2F0%2FDownload.aspx%3Fd%3DUNEP-POPS-POPRC.9-Side01A-PRES-12-FlintHills.English.pdf&ei=up1nUpHlIor80QWOxoHgCA&usg=AFQjCNFtQJCE8a_riZrso_ipMZgvJBIWFg&bvm=bv.55123115,d.d2k&cad=rja

[28] From the UNEP process it is known that the 1 step process is used in N. America, but there are at least two sites that use the two step process. Para 68 of UNEPS doc. UNEP/POPS/POPRC.7/19/Add.1 states “Two production facilities in North America, and possibly others outside Europe, utilise a "two-step" process. It is unclear what is currently used in the "non-HBCD EPS" process, but at least in the past tetrabromocyclooctane and dibromoethyldibromo-cyclohexane were used (LSCP 2006). There are also concerns about the environmental or health properties of these substances.”

[29] During the UNEP POPRC9 (October 14, 2013) meeting, BASF indicated that they have secure supply of the pFR and intend to switch from HBCDD by the REACH sunset date. Whilst BASF are not the only company operating in the Korea (LG Chem, Ltd., SH Energy & Chemical Co., Ltd., BASF SE, Samsung Petrochemical Co., Ltd. and Kumho Petrochemical Co., Ltd) it is assumed they represent a large proportion of HBCDD demand from Korea.

Tab1e 2.6 Proportion of regions likely to continue to use HBCDD

HBCDD demand	2015-2018	2019
Japan	0%	0%
Americas	50%	0%
Europe	0%	0%
China	100%	50%
Korea	0%	0%
Total	**43%**	**18%**

Notes:

1. The 0%, 50%, and 100% proportions were deliberately used to avoid the impression of false accuracy. These figures are based on expert judgement of the EPS industry but are subject to uncertainty.
2. The total demand figures are relative to tonnages shown in Table 2.5 and the percentages above.

Table 2.6 suggests that Europe should get a higher share of the pFR (compared to its current share of the HBCDD market which is ~44%) since Europe has a large demand for flame retardants and is in the later stages of transitioning away from the use of HBCDD compared to the other regions listed in Table 2.6. The suggestion that Europe gets a higher share of the pFR is further substantiated by the fact that, globally, not all FR EPS producers are predicted to switch away from HBCDD (e.g. some may be able to use a different FR within the two step process) and that some XPS producers may *potentially* switch to another substance. Table 2.7 sets out the estimated proportion of the pFR demanded in the EU and outside of the EU relative to other alternative FR substances available (including HBCDD for non-EU regions). The figures presented in Table 2.7 represent an optimistic perspective that, over time, suggests that alternatives to HBCDD for XPS *other* than the pFR, may be adopted. In the case of FR EPS, it is clear that all EU producers are expected to demand the pFR from 2015-2019.

Tab1e 2.7 Proportion of the pFR demanded relative to other possible alternative flame retardants (including HBCDD for non-EU regions)

Demand for pFR	2015	2016	2017	2018	2019
EU – EPS	100%	100%	100%	100%	100%
EU – XPS	90%	90%	85%	60%	53%
Non-EU (combined EPS and XPS)	56%	56%	55%	52%	74%

Notes:

1. It is optimistically assumed that up to 50% of XPS demand for pFR can be displaced with another FR between 2015 and 2019. This is subject to uncertainty as, like EPS, XPS producers have indicated a preference for the pFR. If XPS producers were to demand the pFR in higher quantities than those currently estimated, the estimated demand for the pFR would increase. The displacement over time of

demand for the pFR in XPS towards other alternatives reflects improvements in the supply of these alternatives based on identical product utilisation rates to those presented in Table 2.2 for the pFR and based on a product qualification period of 18-24 months (see AoA for further details).

2. Non-EU figures are calculated as follows: The starting point for the non-EU estimates is that 43% of global demand for FRs will be met by HBCDD (and therefore up to 57% will be met by the pFR) in 2015-2018 (See Table 2.6) and this proportion will fall to only 18% in 2019. Based on industry expert judgement, it is estimated that 80% of non-EU sales are for EPS and 20% for XPS. It is also assumed that 100% of non-EU EPS producers will switch to the pFR whilst the switching behaviour of non-EU XPS producers will be identical to that of EU-XPS producers. To convert from HBCDD demand to pFR, a ratio of 1:1.3 and 1:1.1 are used for EPS and XPS respectively. Further, it is assumed that alternative FRs for XPS are as effective as the pFR.

An important consideration is the effectiveness as a flame retardant of the pFR compared to HBCDD on a weight basis. In order to meet fire safety requirements for EPS and XPS it is estimated that compared to HBCDD 1.3 times the amount of pFR is required for EPS[30] and 1.1 times the amount is required for XPS[31].

The final consideration in the model is that demand for EPS and XPS are likely to grow over time. The annual growth in demand for EPS and XPS used in the model are set out in Table 2.8.

Tab1e 2.8 Annual growth in demand for EPS and XPS over time

	2011	2012	2013	2014	2015	2016	2017	2018	2019
EU - EPS	4%	0%	0%	0%	3%	5%	6%	7%	7%
EU - XPS	3%	0%	0%	0%	3%	4%	5%	6%	6%
Non EU - EPS	0%	0%	0%	0%	0%	0%	0%	0%	0%
Non EU - XPS	0%	0%	0%	0%	0%	0%	0%	0%	0%

As shown in Table 2.8, there is a conservative assumption that there is no growth in the market for EPS and XPS outside of the EU from 2011-2019 and that there is no growth in the EU market over the period 2012-2014. It is assumed post-recession (by 2015) that EU

[30] The increase in the volume of the FR needed when switching from HBCDD to the pFR is thought to range from 25-50% based on responses received by consortium members.

[31] The increase in the volume of the FR needed when switching from HBCDD to the pFR is thought to range from 1-5% based on responses received from a consortium member. However based on the Knauf presentation at the UNEP POPRC9 (October 14, 2013) meeting who make XPS in large volumes, it was indicated that ~10% more is needed.

demand will slowly return to pre-recession levels given regulatory drivers for energy efficiency in buildings by 2020 (and beyond). If more optimistic growth rates were used, the relative demand for pFR would be much higher than current modelled estimates.

Table 2.9 summarises the results of modelling. Global demand for the pFR is estimated at 30.8kt in 2015 rising to 35.9kt in 2019. The estimates take into account all the considerations outlined above such as: (i) the continued use of HBCDD in some regions, (ii) the effectiveness of the pFR relative to HBCDD, (iii) growth rates in demand for EPS and XPS, and (iv) the uptake of other FR alternatives for XPS. Given all these variables, the modelled estimates are subject to uncertainty but are intended to transparently provide a best estimate based on conservative assumptions and EPS industry expert judgement.

Tab1e 2.9 Estimated global demand for pFR (tonnes)

Demand for pFR	2015	2016	2017	2018	2019
EU	17,747	18,560	19,145	18,014	18,456
Non-EU	13,091	13,091	12,958	12,290	17,393
Total	30,839	31,652	32,103	30,304	35,850

Table 2.10 compares expected global supply and demand of the pFR. It shows that there is expected to be a shortfall of supply compared to demand over the 4-year authorisation review period. The shortfall occurs over the entire authorisation period, from 2015-2019 and not just before the sunset date (August 2015). As noted earlier, there are significant uncertainties over both supply and demand estimates, and where possible optimistic (but also plausible) figures have been used. Therefore, in reality, the shortage in the volume of the pFR supplied could be worse than currently estimated.

Table 2.10 Estimated Global supply and demand of the pFR for 2015-2019 (tonnes)

	2015	2016	2017	2018	2019
Demand for the pFR	30,839	31,652	32,103	30,304	35,850
Supply of the pFR	23,350	29,850	31,350	31,350	31,350
Deficit/surplus	**-7,489**	**-1,802**	**-753**	**1,046**	**-4,500**

The most critical points during the proposed authorisation period are in 2015 when there is significant demand for the pFR in Europe and in 2019 with the possible removal of the exemption under the UNEP regulation meaning a large proportion of producers will switch away from HBCDD and opt for the pFR.

If there is a significant excess in demand for the pFR over time, it is possible that pFR suppliers may increase supply (as one would expect based on economic theory in a fully functioning market free of distortions/barriers to entry). The likelihood and the extent to which an expansion in the production capacity of pFR manufacturers is necessary will become clearer over the course of the review period.

Importantly, whilst the deficit in the initial years considered is based on observed switching that has occurred from HBCDD to the pFR, the deficit in 2019 is *predicted* based on other EPS/XPS producers switching due to the expiry of the UNEP HBCDD ban exemption. The deficit figures are therefore directly applicable to the consortium, since it is reasonable to assume that non-EU EPS producers not in the consortium and XPS producers have secured long term contracts in place with the pFR producers for guaranteed supply.

Further information has been provided confidentiality concerning the specific demand needed of the consortium and therefore how much pFR and HBCDD might be needed.

2.4. Formulation of FR EPS (Use 1)

Establishing and mapping out the supply chain is a fundamental component of the SEA process as it establishes the life cycle of the substance, the actors involved in its use and in the use of articles derived from it as well as the overall size of the market.

As defined in the ECHA SEA guidance (2011), a 'supply chain' refers to the system of organisations, people, activities, information and resources involved in moving a substance from supplier[32] to customer; i.e. the links from manufacture/importers[33] to downstream users[34] and consumers, including use of articles containing the Annex XIV substance.

2.4.1 EU-27 Supply chain information

This section focuses on information for the EU formulation of FR EPS based on readily available statistical information, the confidential CMAI (2009) study[22] and confidential information provided by EPS members via a questionnaire (see Appendix C). The CMAI (2009) study was based on EU27+2 data for the year 2007. The data is, however, sufficiently disaggregated in order to produce results specifically for the EU27.

[32] Defined in the ECHA SEA guidance as suppliers of raw materials or intermediates (e.g. formulations) required in order to manufacturer a substance.

[33] Defined in the ECHA SEA guidance as any natural or legal person established within the Community who manufactures a substance within the Community (manufacturer) or who is responsible for import (importer) (Art 3(9) and (11)).

[34] Defined as any natural or legal person established within the Community, other than the manufacturer or the importer, who uses a substance, either on its own or in a preparation, in the course of his industrial or professional activities. A distributor or a consumer is not a downstream user. A re-importer exempted pursuant to Article 2(7)(c) shall be regarded as a downstream user.

Table 2.13 below show how EPS pellet sales are distributed between flame retardant uses (62%) and non-flame retardant uses (38%).

Table 2.13 EU 27 sales for EPS (2007)

Uses of EPS	Total (kt)	% (EU27 total)
Non-FR EPS for packaging uses	295	21%
Non-FR EPS construction uses	239	17%
FR EPS for construction uses	860	62%
Totals	**1,394**	**100%**

Source: CMAI (2009) – Confidential Report

The use of FR EPS for packaging is not covered in the CMAI (2009) study as it is assumed to make up a very small proportion of EU27 sales for EPS. However, initial responses to the questionnaire with EPS producers suggest that packaging represents between 1-16% of total FR EPS sales, although typically towards the lower end of this range. Authorisation is not being sought for packaging applications so is not assessed further.

The figures shown in Table 2.13 are somewhat misleading as the results are affected by other factors such as the use of flame retardants for some key EPS applications[35]not being mandatory for Nordic countries. Excluding these countries, almost 85-100% of EPS used in construction applications is flame retardant (FR). As HBCDD is only used in FR EPS, the focus of this section and the study itself is the FR market for EPS.

Table 2.14 summaries information about the market for FR EPS bead production for the year 2007. Table 2.14 therefore excludes data on non-FR EPS production. It shows there are 22 FR EPS bead production facilitates in the EU 27, with the Netherlands and Germany being the Member States with the most sites. Combined total direct and indirect employment is estimated at 2,985 across the EU27 for 2007.

[35] This is explained further in Section 2.5.2 (Regulatory drivers for FR EPS).

Table 2.14 Estimated market information for FR EPS bead production (2007)

Member State	Number of FR EPS production facilitates	Directly employed	Indirectly employed
Total	**22***	**1,243**	**1,742**

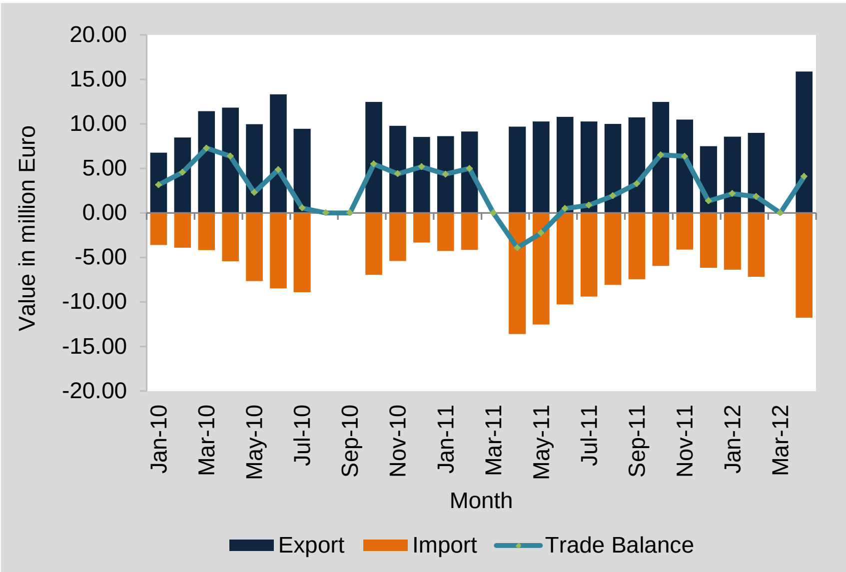
Source: CMAI (2009) – Confidential Report – Totals only shown.

*Updated confidential information on totals has also been provided to ECHA indicating that there are 4 four sites than those indicated in the total since 2009.

Currently, beads not expanded/blown (referred to as EPS 'pellets' in this study) are imported into and exported outside of the EU27, with the EU being a net exporter. This is illustrated in Figure 2.2, which is based on United Nations Commodity Trade Statistics for Expansible Polystyrene (SITC: 572.11)[36].

Figure 2.2 EU27 Imports and Exports of expansible polystyrene (€m[37])

Trade between EU–27 and the rest of the World of Expansible Polystyrene (*in Millions of Euros*)



Sources: United Nations Commodity Trade Statistics (UN Monthly ComTrade) Database; European Central Bank (ECB).

EPS pellets do not meet the definition of an article[38] and will be considered a mixture. Therefore, if an authorisation is not granted / applied for, after the sunset date, it will not be

[36] http://unstats.un.org/unsd/cr/registry/regcs.asp?Cl=14&Lg=1&Co=572.11

[37] Data to be gathered over a 5 year period to establish if there has been a longer trend

[38] See the assumptions set out at section 1.2.4 Status under REACH of this document.

possible to formulate FR EPS pellets in the EU to sell to the rest of the world. It will also not be possible to import FR EPS pellets into the EU (as it cannot be used without authorisation).

2.4.2 Consortium specific supply chain

Further information has been provided confidentiality concerning the consortium supply chain; raw materials used, their downstream users, prices and sales revenue.

2.5. Manufacture of FR EPS (Use 2)

An EPS converter uses unexpanded EPS pellets to make final EPS products. The EPS pellets are converted to expanded beads using steam. The expanded beads are then moulded into boards or the desired shape (e.g. insulation boards).

This section sets out some of the key findings from the EPS converter market questionnaire (see Appendix E). These data were collected internally within the consortium, but through direct contact with their customers who make FR EPS products for building applications. Whilst the relative share of FR EPS compared to non-FR EPS is discussed in this section, the focus is on FR EPS, since non-FR EPS does not require HBCDD.

It is assumed that an EPS final product (e.g. blown beads or boards) would meet the definition of an article, but once expanded, the transported costs of moving EPS beads/products (which are very light products) into the EU would typically be uncompetitive relative to other FR products on the market (e.g. mineral wool, PUR/PIR). The CMAI (2009) study indicates that it is only competitive to transport expanded EPS beads typically within 200 km of final customers[39]. As a result the industry is structured with numerous EPS converters across the EU.

Table 2.18 summarises information about the FR EPS converter market for the year 2007, and excludes data on non-FR EPS conversion. It shows there are 587 FR EPS bead converter facilities in the EU 27 (not all of which will be customers of the consortium), with Poland having the most sites (although ~75% of Polish sites are very small units processing 250 tonnes of EPS on average per year). Total direct and indirect employment is estimated at 23,271 across the EU27 for 2007.

[39] This highlights that EPS boards have a density of around 30kg/m3, which makes their transportation very expensive (in effect, much of it is transporting air). As a result around 95% of all EPS boards are sold within a 200km radius of where they are produced.

Table 2.18 Estimated market information for FR EPS converter production (2007)

Member State	Number of EPS converter facilitates	Directly employed	Indirectly employed
Total	587	11,082	12,189

Source: CMAI (2009) – Confidential Report – Totals only shown

2.5.1 What products do converters make?

A total of 17 questionnaires were received from eight members of the consortium, with some members providing responses by country. Given the good response rate and level of detail provided, the following summary is provided at EU level (noting variations exist across the EU):

- Range of insulation products that converters produce:
    - Most converters specialise in making EPS only products;
    - Some converters also make XPS products; and
    - A minority of converters also make or distribute other insulation products (e.g. PUR/PIR, mineral wool) but this only accounts for <10% of products made/distributed.

- FR EPS accounts for a large proportion of EPS production:
    - *Typically* between 70-98% of EPS made is FR for construction applications; and
    - *Typically* between 2-30% of EPS made is non-FR (in certain building applications and packaging applications).

The type of EPS made is region/country specific and is predominately driven by building regulations rather than other market factors such as price and availability. Therefore, in some countries EPS convertors may in fact be predominately making non-FR EPS (e.g. >30% FR EPS) or almost all FR EPS. This is discussed further below.

2.5.2 Regulatory drivers for FR EPS

In 2008, Dr Jurgen Troitzsch undertook a study to provide an expert opinion on the relevance of FR EPS and FR XPS and the role of HBCDD to meet fire safety requirements for construction products in Europe (Troitzsch 2008[40]). As part of that study Dr Troitzsch concluded that "*flame retarded EPS/XPS foams are compulsory in the large majority of the*

[40] (Troitzsch 2008) – "*The relevance of hexabromocyclododecane for polystyrene EPS/XPS foams to meet fire safety requirements for construction products in Europe*" A report for the European HBCD Industry Working Group – formed by the European Chemical Industry Association CEFIC and the Association of Plastics Manufacturers PlasticsEurope.

EU and EFTA member States for meeting the respective national fire safety levels requiring at least Euroclass E" (See Section 2.2.5 of the AoA for further details of the Euroclass System and European Fire Regulations). The study reviewed fire safety requirements for insulated systems in buildings to respect to national building regulations of European states. The report states that while the majority of European states still have prescriptive requirements, some of them have introduced performance-based ones.

Requirements may apply to the EPS/XPS foams alone or for a complete insulation system consisting of the foam and a covering. In addition, storage and insurance requirements may be relevant. Figure 2.3 summarises the findings of fire safety requirements in terms of whether there is a requirement to use FR foam insulation or whether non-FR foam insulation is acceptable. Figures 2.3a and 2.3b below indicate the broad differences in flame retardant requirements for building insulation materials for wall and external wall applications across Europe. Results are based on the EU15 and updated with information from the consortium members).

Figure 2.3a: EU fire standards for building insulation material for walls

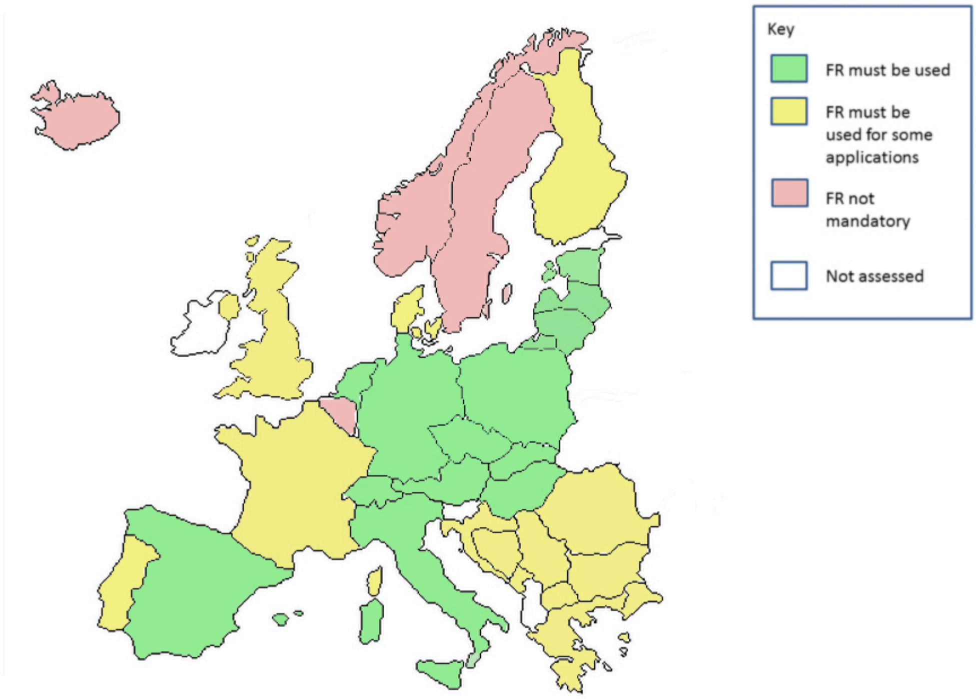
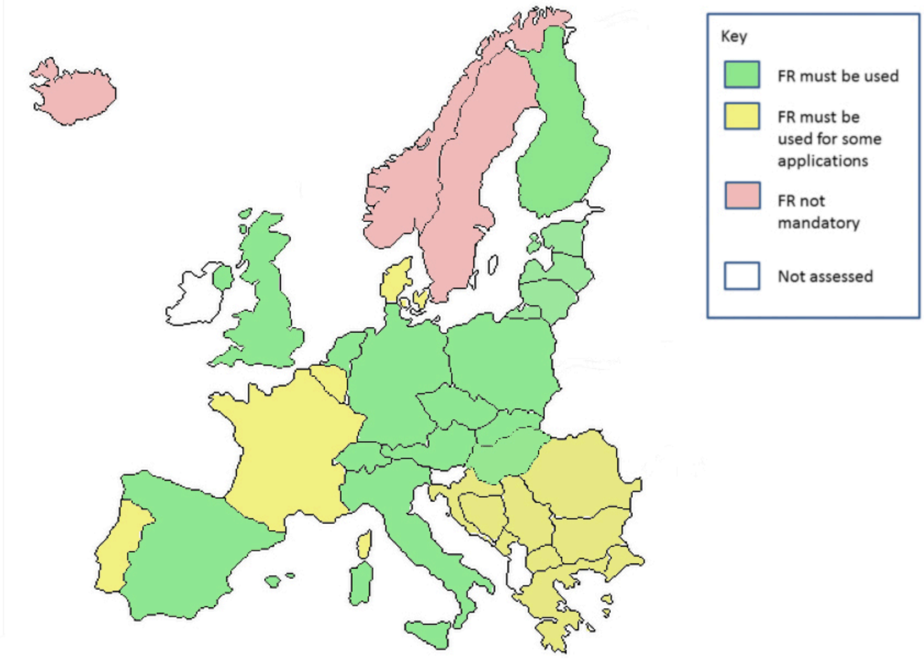


Figure 2.3b: EU fire standards for building insulation material for External Wall (ETICS)



The information in Figures 2.3 a and 2.3b has been adapted and updated from Exiba et al. (2006), Troitzsch (2008) and direct information from EPS manufacturing companies on the basis of understanding of requirements for FR EPS for specific uses in Baltic and South East European states. This also covers some of the EU candidate and potential candidate states (such as Kosovo, Macedonia (FYROM), Bosnia Herzegovina, Serbia and Montenegro), which were missing from Exiba (2006) and Troitzsch (2008).

Troitzsch (2008) suggests that most EU countries are required to use FR EPS (highlighted in green in Figures 2.3a and 2.3b) and cannot use non-FR EPS. Some countries use FR EPS but this is not necessarily mandatory for all applications (highlighted in Figures 2.3a and 2.3b in yellow). The use of FR EPS is, however, mandatory for the following specific FR uses (Troitzsch, 2008):

- In Denmark and Finland, "building material used as components of construction products must at minimum meet Euroclass E";

- In France, "apart from exceptional cases, flame retarded EPS/XPS foam grades must be used"; and

- In Portugal, "there are no minimum requirements for the use of EPS/XPS foams. However, for technical assessments made by notified bodies, external thermal insulation composite systems (ETICS) and other foam applications in building must at least meet Euroclass E".

In other EU/EEA countries assessed, it is not mandatory to use FR EPS (highlighted in Figures 2.3a and 2.3b in light orange) but this does not mean it is not used.

According to the consortium, total EU use of construction applications (e.g. all insulation material, not just EPS) has grown by 30% in the period 2005-2011 due to the increase of insulation demand linked to the introduction of Energy Performance of Buildings Directive (EPBD)[41]. Over the same period, FR EPS consumption (sales) in construction has increased whilst non-FR EPS sales have declined. They suggest that this is being driven by the market preferring FR EPS due to compliance to fire safety regulations.

The countries where demand for FR EPS has grown over the period 2005-11 are: Sweden, France, United Kingdom, Greece, Finland, Switzerland, Austria, Italy, Germany, Romania, Czech Republic, Slovak Republic and Hungary. This suggests growth has occurred in several countries despite FR insulation not being mandatory.

[41] DIRECTIVE 2010/31/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

of 19 May 2010 on the energy performance of buildings

2.5.3 Main applications of FR EPS

Table 2.19 provides information on the EU market for FR EPS by type of building use. The EUMEPS information was gathered at the EU level via national association declarations of data from their customers.

Table 2.19 Main applications of EPS within construction – EUMEPS estimate

Further information has been provided confidentiality identifying the main uses of FR EPS and use specific values

Based on qualitative information (i.e. a list of uses) provided by members, it would seem that FR EPS is the dominant material on the market for the following applications:

- ETICS
- Flat roof insulation
- Floor insulation
- Pitch roof insulation

Figure 2.4 depicts some of the end uses of EPS in building applications.

Figure 2.4 Summary of EPS final uses

Source: Plastics Europe[42]

2.5.4 The EU FR EPS market

According to the CMAI (2009), there are a total of 22 FR EPS formulation sites in the EU and 587 manufacturing (converter) sites specifically using FR EPS. Overall there is a

42 "*Building our future, Sustainable Insulation with Polystyrene Foam; Energy efficiency, safety, versatility, cost-effectiveness*" – A publication by Plastics Europe

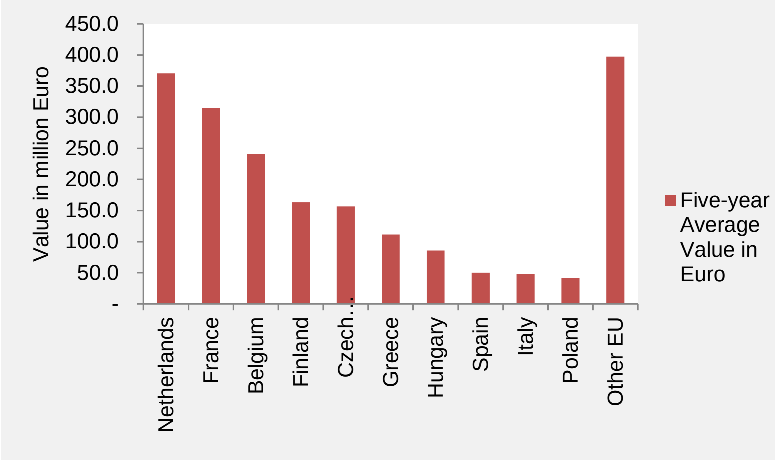
relatively low market concentration, and no single supplier dominates the market. Demand is also diffuse across EPS convertors. Data shown in Figure 2.2 also illustrates imports into the EU indicating that EU-based FR EPS producers compete with international competitors to supply to EU EPS converters. Note also that EPS also competes with alternative FR products such as XPS, mineral wool, PUR and PIR.

The relative market share of FR EPS, compared to alternative FR products, is largely attributed to its price-competitiveness and the desirable function of being very light and easy to use as a final product. In construction applications, use of FR EPS reduces costs in transport, handling and overall construction time to insulate buildings (as it is easy to cut and mould). It is also a product that is not a skin irritant (e.g. compared to mineral wool), and thus suitable to use without personal protective equipment (PPE), such as gloves, goggles or a mask for example.

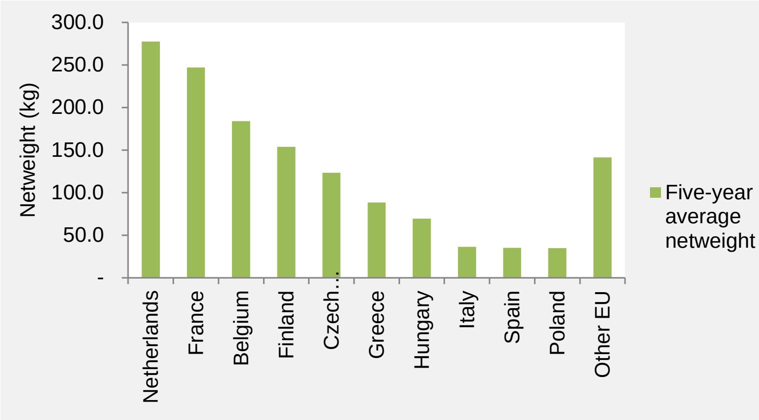
As noted in Section 2.5, EPS pellets (i.e. un-expanded beads) are traded into and from the EU, with the EU being a net exporter (see Figure 2.2). The Netherlands has been the EU's largest exporter of EPS pellets over the last five years, followed by France and Belgium (see Figure 2.5- No data exists on Germany although they are expected to be one of the main exporters of EPS pellets). On the other hand, Poland, Germany, and France are the largest importers of EPS pellets (see Figure 2.6).

Figure 2.5 EU27 Exporters of EPS pellets

Top 10 EU27 Exporters of EPS pellets (*in million Euro*)



Top 10 EU27 Exporters of EPS pellets (*in million Kg*)



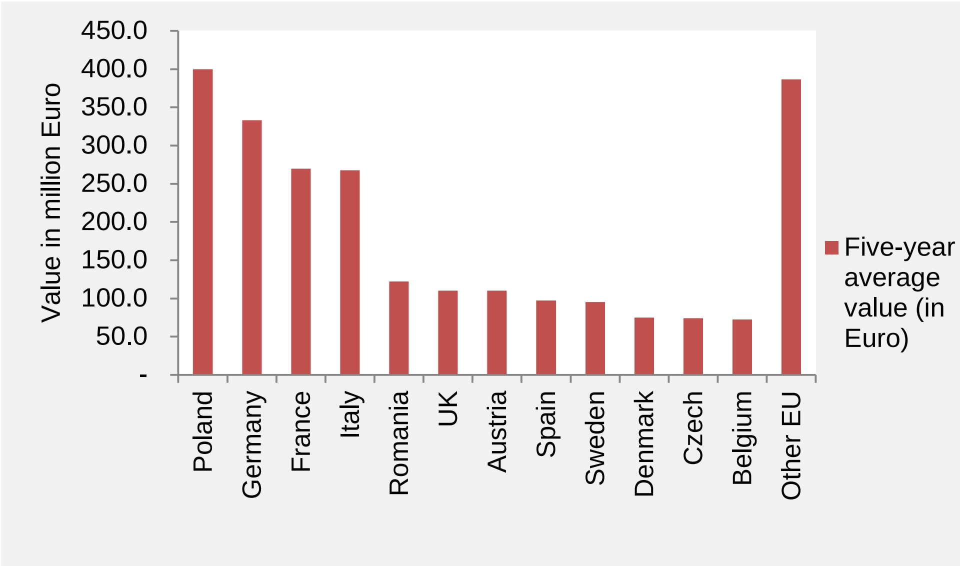
Sources: United Nations Commodity Trade Statistics (UN ComTrade) Database;

European Central Bank (ECB).

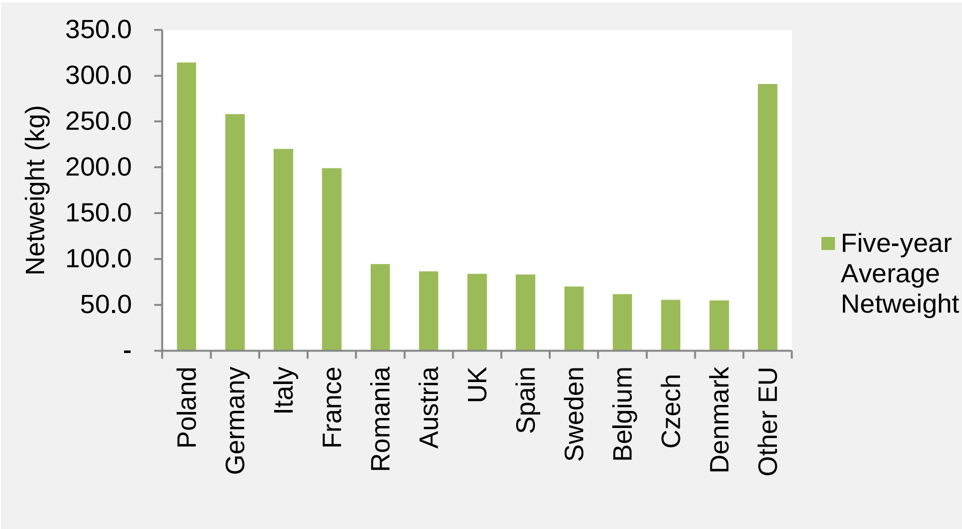
Note: 2011 Exports Data for the Netherlands are not available hence a four–year average was used. No data exists on Germany although they are expected to be one of the main exporters of EPS pellets.

Figure 2.6 EU27 Importers of EPS pellets

Top 12 EU27 Importers of EPS pellets (*in million Euro*)



Top 12 EU27 Importers of EPS pellets (*in million Kg*)



Sources: United Nations Commodity Trade Statistics (UN ComTrade) Database; European Central Bank (ECB).

All EPS producers in their questionnaire responses (See Appendix C) indicated that they expect demand for FR EPS will increase over time. Demand for FR EPS is derived from the construction sector, through the construction of new buildings and retrofitting/renovation of existing buildings. There is expected to be an increase in demand for FR EPS due to requirements for greater energy efficiency in buildings. For example, the EU climate and energy package, agreed in 2009 (the "20/20/20 Package") requires[43]:

- A 20% reduction in EU greenhouse gas (GHG) emissions from 1990 levels;
- Raising the share of EU energy consumption produced from renewable resources to 20%; and
- A 20% improvement in the EU's energy efficiency.

The energy efficiency of buildings is critical in achieving the above targets (as well as other legisalation such as the EU Emissions Trading Scheme, Renewable Energy Directive and Energy Efficiency Directive). Eurostat estimate that buildings (household and commercial/retail) account for around 42% of energy demand with the remaining proportion coming from transportation (32%) and industry (26%)[44]. This is confirmed by the EU GPP Technical Background report on Thermal Insulation (EC 2010[45]) which indicates "that buildings are responsible for 40-50% of Europe's energy use and the largest share of energy in buildings is heating. It is thought that up to 50% of buildings in Europe are un-insulated".

Figure 2.7 shows that over 50% of the energy demanded in buildings is for space heating. Therefore, ensuring effective insulation in buildings (through the use of insulation materials such as EPS) will help reduce energy consumption, demand and associated GHG emissions.

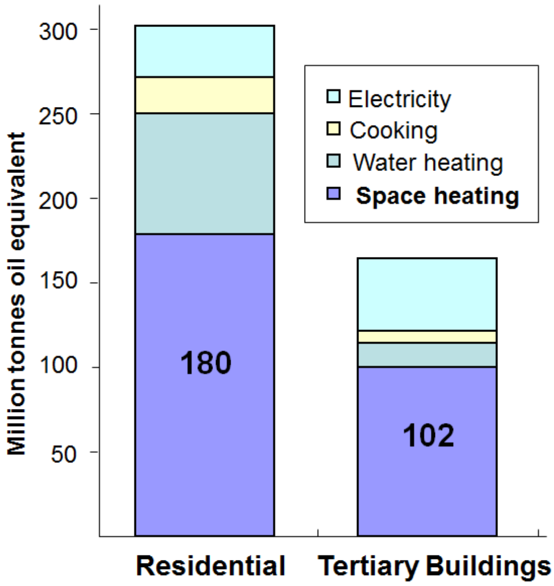
[43] http://ec.europa.eu/clima/policies/package/index_en.htm

[44] Source: Eurostat (code: tsdpc320):

http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database

[45] (EC 2010) – "*Green Public Procurement Thermal Insulation Technical Background Report*" – Report for the European Commission (June 2010).
http://ec.europa.eu/environment/gpp/pdf/thermal_insulation_GPP_%20background_report.pdf

Figure 2.7 Energy consumed within buildings[46]



Source: Ineos Styrenics

2.5.5 Expected market changes over time

All members of the consortium were in agreement that in the absence of inclusion in of HBCDD in Annex XIV of the REACH Regulation, demand for FR EPS would grow (post-recession) due to policy targets to make buildings more energy efficient. From the questionnaire sent to an EPS convertors (See Appendix E) respondents predict that EU demand for FR EPS would increase over the period 2014-2020 from between 0.5% to 8% per year. Some of the reasons for the predicted increase in demand for FR EPS are:

- Rising demand for FR EPS over non-FR EPS (in part driven by fire safety regulations);
- EU policies which would encourage greater building energy efficiency; and
- Rising heating fuel costs, making insulation more cost-effective (because the payback of costs is achieved over a shorter period of time).

2.6. The EU thermal insulation market

The EU GPP report (EC 2010) notes that there already exist a number of materials which can be used for thermal insulation, although not all these materials will be suitable substitutes for FR EPS for all building applications (this is described further in the Analysis of Alternatives).

[46] Tertiary buildings include commercial service buildings and public buildings such as hospitals.

According to the EU GPP study, existing eco-labels and criteria define thermal insulation using the four categories below:

- **Inorganic mineral fibre**: The below products are often collectively referred to as mineral wool (also hereafter termed together as mineral wool):

    - Stone wool is based on natural minerals, e.g. volcanic rock, typically basalt or dolomite, and recycled post-production waste materials, melted, spun into fibres and then mixed with binder and impregnation oil. There is a wide variety of products ranging from loose materials suitable for cavity wall insulation, to rolls and light boards for loft insulation and dense slabs used for light load bearing application to floors and roofs. The range includes slabs, pre-formed pipe insulation and wired matting.

    - Glass wool is made from sand, limestone and soda ash with a high proportion of recycled glass and other minerals. These are melted, spun into fibres, and mixed with organic resins before curing into products. These may be used for similar applications as stone wool.

    - Slag wool is made from blast furnace slag (waste).

- **Petrochemical derived**

    - Polyurethane foam (PUR) is a closed cell thermoset polymer. It can be applied as rigid foam, blown with CFC-free gas (generally HFCs, CO_2 or pentane), or as prefabricated products which have been moulded into discrete shapes. This product can be used as cavity wall insulation or as roof insulation, floor insulation, pipe insulation, insulation of industrial installations, ships as well as cooling and refrigeration equipment.

    - Polyisocyanurate foam (PIR) is also a closed cell thermoset polymer with many similarities to PUR, above. The key difference is in the ratio of the polyol and isocyanate co-polymers. PIR is used typically for metal faced panels, roof boards, cavity wall boards and pipe insulation. It is generally accepted that it has better fire resistance properties than PUR.

    - Phenolic foam is also a thermoset polymer; however it can have an open or closed cell structure. In order to use the product as a foam the phenolic resins are mixed with an inorganic acid catalyst and a blowing agent (generally hydrofluorocarbons (HFCs), carbon dioxide (CO_2) or pentane). The product is typically used to insulate pipework, roofs and walls.

    - Expanded polystyrene (EPS) is a rigid cellular form of polystyrene, with an open cell structure. It is a thermoplastic polymer, so can be reprocessed and recycled more easily than thermoset polymers. Building and construction applications account for around two-thirds of demand for EPS; loose beads are used for closed cavity walls, roofs and floor insulation and boards can be produced by fusing beads together. Pentane is used as a blowing agent.

- Extruded polystyrene (XPS) is also a thermoplastic polymer, however it has a closed cell structure and is often stronger, with a higher mechanical performance and is often, in principle, more expensive than EPS. It is made from solid polystyrene crystals and used to make insulation boards for roofing, flooring and wall application. HFCs or pentane are used as blowing agents.

- **Plant/animal derived**

  - Cellulose derived from recycled newspaper, which has been treated with insect and fire resistant chemicals (typically mixtures of borates or boric acid or cheaper alternatives such as aluminium and ammonium sulphates). It can be wet or dry blown. It is sometimes formed into boards but is more usually blown into place. As such it can be used as loft or wall insulation.

  - Cork insulation boards come from cork oak, which is grown in Portugal, Spain and Northern Africa. It is used for flat roof insulation, is lightweight and ranges in thickness between 13 mm and 305 mm. It is a by-product of the bottling cork industry and can be recycled where facilities exist.

  - Wood fibre boards are rigid building boards made from sawmill off cuts that are pulped, soaked and formed into boards.

  - Sheep wool, as the name suggests, comes from new or recycled wool. It is available in rolls or batts that have been treated with fire retardant chemicals. Sheep's wool may require pre-treatment to remove pesticide residue from sheep dip and to prevent moth attack.

  - Cotton insulation is made from post-industrial recycled cotton textiles.

  - Hemp fibre contains fibres from the plant hemp, waste cotton fibres and a small amount of thermoplastic polyester binding fibres. It is available in rolls for wall, roof and floor insulation.

  - Flax insulation is formed by combining fibres from the plant flax, which is grown in Europe, with polyester, diammonium hydrogen phosphate and borax.

  - Compressed straw is plant straw (commonly from wheat, rice, rye or oats) fused together. Available in insulation boards with heavyweight paper on each side.

- **Other**
  - Foamed glass (Cellular glass) is formed from a reaction between glass and carbon at high temperatures and has a cellular structure which is impermeable. This makes it ideal as a barrier against soil humidity. It is typically blown with CO_2 with the addition of sulphur gases.
  - Aerated glass is also produced from recycled glass and is a closed cell material.
  - Expanded clay pellets are small and expand at very high temperatures to become lightweight, porous and weight-bearing.
  - Vermiculite consists of a complex hydrated aluminium magnesium silicate. It is exfoliated into pellets which can be used as loose fill loft insulation.
  - Foil products consist of a number of layers of aluminium foil between layers of polyester wadding, or other insulation products, such as glass wool. The product works by reflecting heat and is often used in roofs and walls in warmer regions to reduce the flow of solar heat into buildings. At present there is no agreed standard for measuring the performance of foil insulation products and there is some difference of opinion on how well foil products perform in terms of their thermal insulation properties. "Work is currently being undertaken by CEN/TC89 working group 12, entitled "reflective insulation products" to address this issue. This working group is investigating the thermal performance of thin multi-layer reflective insulating products, such as multi-foil insulation.

According to the Klif (2011)[47], as shown in Table 2.20, mineral wool (stone and glass) is the dominant material in the EU (>50%) followed by plastic foams (e.g. including EPS and XPS) whereas in Asia, plastic foams is the dominant material.

[47] (Klif, 2011) – "Alternatives to use of flame retarded EPS in buildings" – Report for Norwegian Climate and Pollution Agency (Klif)

Table 2.20 Insulation market for Asia and Europe

Region	Market size (€)	Plastic foams	Stone wool	Glass wool	Other
Asia	2.5 billion	72%	8%	12%	8%
Europe	6.5 billion	40-45%	25-30%	25-30%	5%

Source: Klif (2011)

According to Shell (2012)[48] EPS has a 35% share of the EU market, as shown in Table 2.21.

Table 2.21 EU insulation market share

	Mineral Wool	EPS	XPS	PUR	Other
Market share	50%	35%	4%	8%	3%

Source: Shell (2012)

2.7. EPS Production Process

2.7.1 Formulation of FR EPS (Use 1)

EPS is manufactured by mixing the substance hexabromocyclododecane, with styrene at low temperatures before charging into a closed reactor and polymerising at reaction temperature (approximately 90-120^{o}C). Alternatively, HBCDD is not pre-mixed with styrene, but added to the reactor in the form of dry powder. The HBCDD is trapped within the polymer matrix during polymerisation. An expansion agent, pentane, is added to the reactor during polymerisation (at a temperature of approximately 130^{o}C) and is absorbed by the polymer droplets ('beads' / 'pellets'); this provides the expansion for the pellets later in the conversion process. The HBCDD is incorporated as an integral and encapsulated component within the polymer matrix with uniform concentration throughout the bead (ECHA 2009).

A number of substances are added into a reactor in a polymerisation process in order to make expanded polystyrene (EPS) pellets, namely:

- Water
- Styrene (monomer)
- Suspension aid

48 (Shell 2012) – "*Building on the benefits of EPS*" – A publication in Shell Chemicals Magazine: Winter/Spring 2012; Available at: http://s08.static-shell.com/content/dam/shell/static/chemicals/downloads/aboutshell/magazine-spring-2012buildingbenefitseps.pdf

- Polymerisation Initiator (organic peroxides)
- Waxes
- Plasticisers
- Pentane (blowing/expansion agent)
- HBCDD (as a flame retardant)
- Peroxide (synergist)
- Infrared absorber: carbon black, graphite (optionally used in grey EPS only). This can be added to the reactor or added during a second stage
- Colourants (optional)

After the initial polymerization is completed, the reactor is cooled down and the EPS pellets are fed to a centrifugal system (via a slurry tank/silo) in order to separate and remove water from the EPS beads. Approximately 98% of water is removed at this stage which is sent to a settlement tank (see also below on the 'mass process').

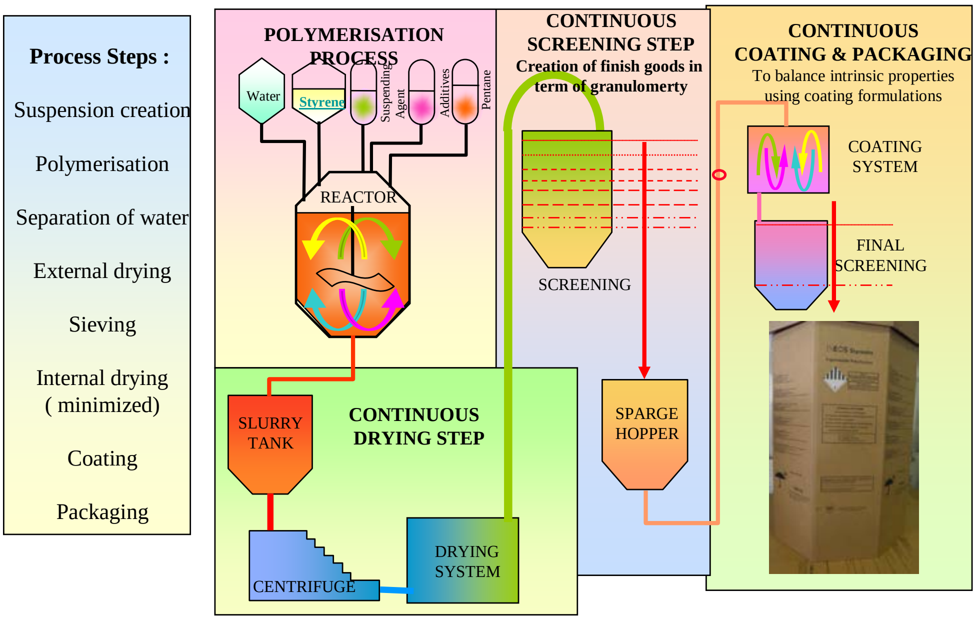
The EPS pellets are dried (by air blowing) to remove the remaining water (ca. 2%). The EPS pellets are then sent to a silo for sieving. The EPS pellets are then filtered, coated and packed into large cardboard containers (with a plastic liner) ready for transportation to EPS converters (manufacturers of EPS articles). The concentration of HBCDD in terms of weight in EPS pellets is typically 0.7%.

The mass process

A variation to the EPS manufacturing process is the mass process. In the mass process HBCDD directly added to the melted polystyrene. All the additives including pentane and HBCDD are mixed in melted polystyrene using mixing equipment such as static mixer or extruders. The EPS then is produced by micro-granulation using an underwater pelletizer. The water is separated from the EPS pellets using a centrifugal dryer. The process water is circulated in a closed-loop system. The EPS pellets are then coated and packed in large cardboard containers as in the suspension process.

The concentration of HBCDD in terms of weight in EPS pellets is between typically around 1 %. The EPS pellet production process is summarised in Figure 2.8 below.

Figure 2.8 EPS pellet production process



Source: Ineos Styrenics

2.7.2 Production of FR EPS (Use 2)

The EPS pellets are converted to expanded beads using steam. The expanded beams can then be moulded into boards and shapes (e.g. insulation boards, specific shapes for packaging).

The five main manufacturing stages are set out below[49]:

1. Pre-expansion: The FR EPS pellets are expanded with the help of steam in an atmospheric or pressurised stirred vessel to form larger beads, each consisting of a series of non-interconnecting cells.

2. Conditioning (Curing, maturing): The beads still contain small quantities of both condensed steam and pentane gas. The beads are stored in aerated silos to cool and as they cool, air gradually diffuses into the pores, lowering the pentane (blowing agent) to the optimised ratio prior to moulding.

3. Moulding: The beads are moulded to form boards, blocks or customised products, where steam and perforated aluminium moulds are used to shape/fuse each bead to its neighbours, thus forming a homogeneous product.

[49] Based on details provided by EUMEPS and Monotez websites: http://www.eumeps.org/manufacturing_4106.html?psid=48b0867885827f241ef221fd4693fc2d & http://www.monotez.com/displayITM1.asp?ITMID=79

4. Shaping (Block cutting): The moulded FR EPS is then stored to cool down, decreasing water content and reaching dimension stability equilibrium. The moulded block is removed from the machine, and blocks are cut in boards or in specific shapes with hot wires. It is also possible to use other special techniques such as drilling or blade cutting.

5. Post-production processing: The finished product can be laminated with foils, plastics, roofing felt, fibreboard or other facings such as roof or wall cladding material.

A simple illustrative video is also available on the EUEMP website on making EPS pellets and EPS conversion to boards/specific shapes[50].

2.8. Risks from short term continued use of HBCDD

2.8.1 Existing regulatory requirements

HBCDD has already been the subject of an evaluation under the existing substances regulation (ESR) Risk Assessment procedure (see EU RAR, EC 2008). Risks for the environment (aquatic compartment) were identified for some sites involved in EPS formulation including the generic scenario. In addition, HBCDD was assigned as having persistent, bioaccumulative and toxic (PBT) properties. Therefore a risk of secondary poisoning was identified because of a major concern that accumulation of PBT substances in the food-chain may result in unpredictable effects in the long term. A Risk Reduction Strategy was formulated, but was not completed before the transition procedure to REACH. The rapporteur (the Swedish Chemicals Inspectorate) proposed that HBCDD be subject to Authorisation under REACH (by inclusion in Annex XIV).

Due to its persistence, (eco)toxicity potential for bioaccumulation and long range transport, a global ban on HBCDD is currently being considered under the framework of the Stockholm Convention on Persistent Organic Pollutants[51]. It is understood that the outcome of a UNEP meeting in October 2012 recommended that EPS with uses in buildings should be exempt from the POPs convention. HBCDD is also included on the list of substances added to a proposal to revise the RoHS (Restriction of Hazardous Substances) Directive. The latter is relevant to the use of HBCDD in electrical and electronics applications only.

[50]http://www.eumeps.org/video____production_of_eps___4782.html?psid=48b0867885827f241ef221fd4693fcd

[51] Persistent Organic Pollutants Review Committee Fifth meeting Geneva, 12–16 October 2009 Item 6 (a) of the provisional agenda* Consideration of chemicals proposed for inclusion in annexes A, B or C of the Convention: hexabromocyclododecane. Document quotes Norway's justification for the POPs proposal "…due to the harmful POP properties and risks related to its widespread production and use, international action is warranted to control this pollution."

The obligations under the REACH Regulation that require the safe use of the substance for all registered uses are of most relevance to this study. The EPS use has been registered under REACH, through the submission of a registration dossier in Phase 1 of REACH. The communication of safe use in the supply chain concerning the appropriate use of risk management measures (RMMs) is via an extended safety data sheet (eSDS).

2.8.2 Hazards and exposure to HBCDD

The composition and properties of HBCDD is described in Section 1.2.1 of this document. Further details properties can be found in Section 1.3 of the CSR.

HBCDD is not readily biodegradable (i.e. is does not breakdown quickly in the environment) in standard studies and does not undergo significant abiotic degradation in water or air. Further details of degradation properties can be found in Section 4.1 of the CSR.

In terms of exposure, as set out in the CSR there are two use patterns which are the subject of this application, included in Use 2 is the use of EPS articles in insulation building uses (service life) and the ultimate disposal of these articles after use. A detailed assessment of the consequences of continued use over time and over different spatial scales is set out in Section 4.3 of this report (with a full report at Appendix F). In addition a mass balance for HBCDD volume used for the manufacture of EPS is set out below in Section 2.9.3.

2.8.3 Mass balance summary

If HBCDD use in EPS continues for four years at a rate of 8,000 tonnes per annum (tpa) (a worst case estimate), a total of 32,000 tonnes of HBCDD would be used. Table 2.22 shows the destination of this tonnage as calculated by the continental modelling. This is discussed in detail in Section 4.3 on environment impacts.

The total release over the service life of an EPS article is included in these releases.

The releases to marine sediment and non-agricultural soil are calculated based on values in the widely used environmental model EUSES, for the areas of sea and non-agricultural soil, assuming the same release patterns and degradation rates as used for freshwater sediment and soil, respectively.

More than 99% of the HBCDD used is incorporated into EPS articles. This means that of the 32,000 tonnes used over a four year period 31,832 tonnes remains in EPS articles. Over the four year period losses of HBCDD are calculated to be from:

- Formulation of EPS (USE 1): 576 kg
- Conversion (including cutting of boards) – (USE 2): 800 kg
- Professional use of boards (including cutting boards on construction sites): 349 kg
- Service life of boards: 230 kg

Releases from Use 1 (formulation/compounding) account for 576 kg. For Use 2 releases from making EPS articles involving cutting, accounts for 800 kg; releases from professional use, (fitting and cutting of boards on construction sites) leads to 349 kg released over a four year period, while losses from service life account for 230 kg loss. (The assessment in the CSR has included professional use and service life in the assessment of Use 2.)

The total amount of HBCDD that is incinerated is 160 tonnes. This volume is from waste from use 1 and 2 (such as incineration of dust, waste EPS and from filters etc.) and also from the end of life of EPS boards. It should be noted that the amount from end of life (e.g. demolition of buildings with HBCDD FR EPS) is contained within the amount that is sent to incineration since it is assumed that in the future (as a result of the Stockholm Convention) that all HBCDD FR waste will be incinerated. This volume of 160 tonnes refers to only those boards that are manufactured in the four year period.

Of the 1.98 tonnes that is released to the environment, 0.32 tonnes is degraded in the environment.).

It is estimated that of the 1.98 tonnes that is released to the environment, 190 kg of HBCDD ends up in sediment (60 kg in freshwater and 130 kg in marine) and 130 kg ends up in soil (80 kg in agricultural soil and 50 kg in other soils).

Table 2.22 Mass balance for HBCDD used over 4 years.

Identifier	HBCDD destination	HBCDD volume (tonnes)	Percentage of total
	In EPS articles	**31832**	**99.47351%**
1	Destroyed by incineration	160	0.49999%
2	In landfill (proportion leaching to water is included in release estimates)	6.5	0.02031%
3	Removal in STP	0.37	0.00116%
4	Degraded in environment	1.29	0.00403%
5	In freshwater sediment	0.06	0.00019%
6	In marine sediment	0.13	0.00041%
7	In agricultural soil	0.08	0.00025%
8	In other soil	0.05	0.00016%
	Total	**32,000**	**100%**
	Total not to the environment (i.e. incineration and landfill = 1+2)	**166.5**	**0.52030%**
	Total to the environment (including to STP and degraded = 3+4+5+6+7+8)	**1.98**	**0.00619%**
	Total remaining in the environment (excluding STP and degraded) = 5+6+7+8	**0.32**	**0.00100%**

3. NON USE SCENARIO

3.1. Introduction

The ‘non-use’ scenario sets out the likely responses if authorisation to continue to use HBCDD to formulate and manufacture EPS (for building applications only) is refused.

As part of the development of the SEA report, a scoping study was conducted initially utilising available information and from consultation with consortium members (i.e. EPS pellet producers). Following the scoping study, consortium members consulted several of their customers (i.e. EPS converters) requesting information, including how they may react to no longer being able supply FR EPS articles.

No direct consultation has been conducted with FR EPS formulators outside of the consortium, as it was considered unlikely that they would participate.

The non-use scenarios presented below assume that authorisation is refused for both use 1 and use 2 especially since the baseline scenario assumes authorisation is granted (i.e. an SEA focuses on the difference between a granted and refused authorisation).

3.2. Use 1: Manufacture of EPS pellets

Table 3.1 sets out possible and likely responses to a refused authorisation for use 1 by the following directly affected actors along the EPS supply chain:

- Suppliers of raw materials used in the formulation of FR EPS; and
- Formulators of FR EPS (the applicants).

The most likely outcomes are then summarised in Table 3.2.

Affected actors further downstream are covered under the “Use 2” non-use scenario in Table 3.3 (See Section 3.3).

Table 3.1 Possible response(s) to a refused authorisation for use 1 (Formulation of FR EPS)

Supply chain	Possible response	Likelihood in practice (with justification)
Suppliers of key raw materials	HBCDD manufacturers will seek to supply HCBDD outside of the EU.	**Likely but limited market** - According to the Sixth Conference of Parties in May 2013 (EC 2013)[52], HBCDD has been recommended to be included on Annex A of the Stockholm Convention on Persistent Organic Pollutants (POPs). This would lead to an international ban on the production, placing on the market and use of HBCDD (unless countries opt out) in HIPS and textiles as well as non-building-related applications of EPS and XPS. The Council of the European Union has recommended that the transposition of the Convention of the Parties (COP) decision is delayed until February 2016[52] in order to align it with Annex XIV of REACH. If authorisation were refused, HBCCD manufacturers would only be able to supply EPS and XPS producers outside of the EU for building use applications only. This exemption, however, would apply for 5 years and be extendable, if necessary, by another 5 years depending on availability of the pFR assuming that there was no other overriding regional legislation (such as REACH in the EU).
	Some HBCDD manufacturers will switch production to the polymeric FR (pFR) once their new production sites are fully operational.	**Likely for those with a licence to make the pFR** - According to the information in an EC report (2013)[52], in March 2011 "Great Lakes Solutions announced it will scale up production of a high molecular weight brominated co-polymer of styrene and butadiene flame retardant (Polymeric FR) suitable for EPS and XPS. It is expected, however, to take several years for

[52] (EC 2013) - Proposal for a COUNCIL DECISION on the position to be adopted, on behalf of the Europe Union, at the Sixth Conference of the Parties to the Stockholm Convention on Persistent Organic Pollutants with regard to the proposal for an amendment of Annexes A and B. Available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2013:0134:FIN:EN:PDF

Supply chain	Possible response	Likelihood in practice (with justification)
		the industry to fully convert to this technology”. “According to the information presented during the eighth meeting of POP RC, currently pilot scale quantities of Polymeric FR are being submitted to downstream users for testing. Plant scale production trials have run successfully and Polymeric FR should be commercially available in 2012 from Great Lakes Solutions-Chemtura Corporation. ICL-Industrial Products recently announced that they are aiming for commercial production by 2014 (10,000 MT). Albemarle (US) will have the chemical commercially available in 2014. The sufficient capacity to replace HBCDD should therefore be reached within 3-5 years” (EC 2013[52]). Further details on the supply and demand of the pFR were presented in Section 2.3.
	Suppliers (e.g. pentane) will attempt to re-distribute supply to uses other than EPS, if there is sufficient demand.	**Unlikely** – If there were excess demand on the market, suppliers would have already increased supply to meet this demand. If non-consortium FR EPS producers have access to the limited supply of the polymeric alternative, they could (if feasible) increase their production and overall market share. This, in turn, will mean for some suppliers that there is only a redistribution of sales. This outcome is highly dependent on the supply of the polymeric alternative and the ability of these EPS producers to increase their production. It is estimated that the EPS consortium in 2007 (the most recent comparative data available) accounted for a substantial part of total EU use of HBCDD in FR EPS. Therefore, the remaining EU EPS producers would have to significantly increase their production (noting that it will not be possible to import EPS pellets into the EU as they do not meet the criteria for an article and that it is not viable to import finished EPS boards or beads).
	Where EPS sales make a large	**Likely** – These suppliers in the short term are likely to see a reduction in demand for their

Supply chain	Possible response	Likelihood in practice (with justification)
	proportion of their sales (e.g. styrene), these suppliers may have to reduce production until sufficient supply of the polymeric alternative is available to all EPS producers to operate at normal capacity.	respective substances (e.g. styrene in particular) given a predicted shortage of supply of the pFR. Once the pFR is available in sufficient supply, then sales could return to current levels assuming there has not been a detrimental impact on the EPS market from possible increased use of final building use products such as mineral wool and PUR/PIR.
Formulator of FR EPS (i.e. pellet producers)	Continue to produce EPS pellets which are not flame retardant (i.e. no HBCDD), which represents a smaller proportion of their market. Overproduce non-FR rather than reduce overall production days (i.e. stockpile).	**Unlikely** – The non-FR EPS pellets market is a smaller proportion of the overall EPS market (38% in total – see Table 2.13) compared to FR EPS (62%). Neither EPS convertors nor EPS pellet producers are likely to risk stockpiling non-FR EPS for a long period of time (given the cost incurred to purchase raw materials and energy consumed) or have storage capacity to do so.
	Some producers may be able to make FR EPS using the polymeric alternative if available (at some given quantity).	**Likely but with limitations** – All members are actively seeking the polymeric alternative but there is predicted to be a shortfall in sufficient supply to meet all FR EPS demand from all consortium members, as well as demand from non-consortium FR EPS pellet producers and XPS producers. Further details on the supply and demand of the pFR were presented in Section 2.3.
	Cease/reduce production days until polymeric alternative becomes available.	**Possible/likely –** Shutdown is a possibility as manufacturers are unlikely to operate plants at low production capacity or 'mothball' them with the expectation of re-gaining market share once there is sufficient supply of the pFR , from those who have gained a competitive advantage from having early preferential access to the pFR.

Supply chain	Possible response	Likelihood in practice (with justification)
	Shut down EU plants and relocate outside of the EU to continue to use HBCDD (but limited to sales of beads outside of the EEA) until polymeric alternative is available in sufficient supply.	**Unlikely –** It will be expensive to write off existing production infrastructure and build a new plant which could cost more than $130m[53] for a production line alone. This cost is disproportionately high given sufficient supplies of the polymeric alternative will be available in the medium term as well as the impending international ban (with time limited exemptions) on HBCDD arising from the Stockholm convention on POPs.
	Use an unsuitable alternative to HBCDD to continue to make FR EPS beads.	**Unlikely –** Based on the Analysis of Alternatives (AoA), there is no other potentially suitable alternative available that could be used in the short term to make FR EPS pellets, factoring in regulatory approval, testing, consumer acceptance and reliability of supply.

[53] Based on publicly available figures for new production line at an existing site in Russia by Alphapor.

Table 3.2 summarises the likely responses to a refused authorisation with likely responses over both the short and long term. It shows that a refused authorisation is likely to have much more significant impacts in the short term than over a longer period of time. This is due to the availability of the pFR in the long term.

Table 3.2 Likely response(s) to a refused authorisation for use 1 (Formulation of FR EPS)

Supply chain	Short term response	Long term response
Suppliers of key raw materials to EPS manufactures	• Several HBCDD producers have a license to make the pFR and are therefore likely to switch production to the pFR alternative once their new production sites are fully operational. • Where EPS sales make a large proportion of sales (e.g. styrene), these suppliers may have to reduce production until sufficient supply of the pFR alternative is available to remaining FR EPS producers on the market and may then return to normal capacity if FR EPS has not lost significant market share to other materials such as mineral wool or PUR/PIR.	• Continue to supply remaining EPS producers on the market who are now using the pFR alternative.
EPS pellet producers	• Some producers may be able to make FR EPS using the pFR alternative if available (unknown quantity). Most are expected to have to cease/reduce production days until pFR alternative becomes available. Some producers may even have to shut down /exit the market.	• Remaining FR EPS producers will make FR EPS with pFR alternative at existing EU plants.

3.3. Use 2: Use of FR EPS pellets

Table 3.3 sets out possible and likely responses to a refused authorisation for use 2 by each actor along the EPS supply chain directly affected:

- Manufacturers of FR EPS (i.e. EPS convertors); and
- End users of FR EPS (insulation market).

The most likely outcomes are then summarised in Table 3.4.

Affected actors upstream were assessed already under the “Use 1” non-use scenario (See Section 3.2).

Table 3.3 Possible response(s) to a refused authorisation for use 2

Supply chain	Possible response	Likelihood in practice (with justification)
Manufacturers of FR EPS (converters)	Stockpile FR EPS beads prior to the sunset date, and effectively take longer to run-down stock, smoothing out any disruption in supply until FR EPS made using the pFR is available.	**Unlikely –** EPS convertors will have storage and capital constraints. They may also view stockpiling as a risk as to whether they can use and sell products using existing stock if authorisation were refused.
	Continue to make non-FR EPS final products and continue (reduced) operations FR EPS production using any available FR EPS pellets made using the pFR alternative.	**Likely based on consultation conducted –** But as noted above non-FR EPS is a much smaller part of the overall EPS market (32% - see Table 2.13) and is unlikely to be viable to just make non-FR EPS final products. There will be limited supply of FR EPS pellets made using the polymeric alternative in the short term and therefore in reality many EPS converters will have to shut down operations.
	Make FR EPS final products using a possible unsuitable alternative.	**Unlikely –** Based on the Analysis of Alternatives (AoA) there is no other potentially suitable alternatives available (other than the pFR) that could be used in the short term to make FR EPS pellets, factoring in regulatory approval, testing, consumer acceptance and reliability of supply.
	Switch (some) production if feasible to make XPS with polymeric alternative	**Uncertain but expected to be limited –** Consultation with EPS convertors (See Section 2.5.1) suggests that most convertors only make EPS (FR and non-FR). Consultation also indicated that, in very limited cases, a small proportion of their portfolio (<10%) concerned making non-EPS products (XPS and PUR/PIR). Depending on the supply of pFR being available for XPS, those converters already making XPS will be able to make continue making XPS.

Supply chain	Possible response	Likelihood in practice (with justification)
End users in the insulation market	Some end users in the insulation market may use non-FR EPS where possible (and/or in combination with other materials to make it FR)	**Unlikely** – non-FR EPS has limited building applications and it is more likely that users will switch to an alternative product that is FR, especially if FR materials are specified by building regulations (See Section 2.5.2).
	Use alternative FR products to EPS e.g. mineral wool, PUR/PIR, XPS with polymeric alternative	**Likely** – Mineral wool is the dominant material on the EU market (50% - See Table 2.21) so it is feasible that some end users may switch to mineral wool for some building applications where it meets technical requirements. PUR and PIR will also be feasible for some building applications but currently have a small market share.
	Use FR EPS final products made with an unsuitable alternative	**Unlikely –** Based on the Analysis of Alternatives (AoA) there is no other potentially suitable alternative that could be used in the short term to make FR EPS products, factoring in regulatory approval, testing, consumer acceptance and reliability of supply. Converters would have to find a raw material supplier which is extremely unlikely since no suitable alternative to HBCDD has been identified.
	Use FR EPS made with the pFR alternative where available	**Likely** – But there will be limited supply of EPS final products made using the polymeric alternative in the short term since the converters are dependent upon a limited supply of EPS raw material with the polymeric FR alternative.
	Import FR EPS final products containing HBCDD as articles from outside the EU	**Unlikely** - The added cost of transport would make it uncompetitive relative to alternative FR products on the market. This is based on analysis included in the CMAI (2009) study that highlights that EPS boards have a density of around 30kg/m^3, which makes their transportation very expensive (in effect, much of it is transporting air). As a result around 95% of all EPS boards are sold within a 200km radius of where they are produced.

Supply chain	Possible response	Likelihood in practice (with justification)
End of life / re-use of waste	Reduction in re-use of FR EPS but no change in supply of building waste	**Likely –** In the short to medium term, supply of waste (FR EPS products in building applications at end of service life) are unlikely to be affected by a refused authorisation as these products (e.g. insulation of buildings) have a service life of 20-30+ years and so in the short term, any waste material will be from historical use of EPS. However, the recommendations from the Stockholm Convention for HBCDD will put in place waste management measures in accordance to Article 6 paragraph 1(d) of the Convention that would ensure that products and articles containing HBCDD are disposed of in such a way that their persistence organic pollutant content is destroyed or otherwise disposed of in an environmentally sound manner. Thus it will not be possible to recycle HBCDD containing materials.
	Recyclers of EPS pellet 'dust' and 'rejected' beads are likely to seek other low cost plastic sources.	**Likely** – Recyclers of waste material from EPS bead production (i.e. dust and 'rejected' beads) will see reduced supply as consortium members are not seeking authorisation for recycled use of rejected beads and dust. Therefore these recyclers' will have to seek supplies elsewhere until EPS producers can provide FR EPS waste material from use of the pFR alternative.

Table 3.4 summarises the likely responses to a refused authorisation with likely responses over both the short and long term. It shows that a refused authorisation is likely to have much more significant impacts in the short term than over a longer period of time. This is due to the availability of the polymeric alternative in the long term.

Table 3.4 Likely response(s) to a refused authorisation for use 2

Supply chain	Short term response	Long term response
EPS converters	• EPS converters will seek to continue to make FR EPS products at reduced capacity using any available made using the pFR alternative. Some converters may have to shut down /exit the market.	• Remaining FR EPS converters on the market will use FR EPS beads with the pFR alternative to continue to make finished FR EPS products
End users in the insulation market	• Use alternative FR products to EPS e.g. mineral wool, PUR/PIR, XPS with polymeric alternative (where this is technically and economically possible). • Use FR EPS with pFR alternative where available.	• Continue to use alternative FR products to EPS. • Use FR EPS with pFR alternative.
End of life / re-use of waste	• No change in supply of building waste but a reduction in re-use of FR EPS due to Stockholm Convention decision not to allow recycling of HBCDD containing materials. • Recyclers of EPS pellet 'dust' and 'rejected' beads are likely to seek other low cost plastic sources.	• Continued end of serve life supply of EPS, and waste from FR EPS bead production made with pFR alternative.

4. COST-BENEFIT ANALYSIS (CBA): USE 1

4.1. Introduction

This section includes an assessment of the impacts of a refused authorisation (i.e. the non-use scenario) relative to the baseline scenario. The assessment is based on the most likely responses identified in Table 3.2, which covers a refused authorisation for use 1 (formulation of FR EPS). All relevant impacts are considered ranging from economic and social impacts to environmental and human health impacts. This is consistent with recommendations set out in the ECHA SEA guidance.

As authorisation is being sought for continued use with a review period of 4 years, the analysis focuses on the impacts during the proposed authorisation period only (i.e. 2016-2019). However, as HBCDD is classified a PBT substance, the environmental impacts are considered over a longer time to account for its persistent presence in the environment. The geographical boundaries of the analysis focus on the EU-27.

Details of the impacts associated with a refused authorisation for use 2 (manufacture of FR EPS) is covered in the next section (Section 5).

4.2. Economic impacts

4.2.1 Market distortions and reduced competition

A refused authorisation for continued use of HBCDD of formulation of FR EPS ("pellets") in building applications (use 1) could:

1. Reduce competition in the EPS market and the wider building-use market that FR-EPS is a component of; and

2. Potentially create a significant distortion in the EPS market.

Reduced (price) competition

As shown in Section 2.3, the polymeric FR (pFR) alternative to HBCDD is not expected to be available in sufficient supply by the sunset date[54] for both XPS and EPS producers to be able to meet the demand for FR EPS and FR XPS. This *could* result in less FR EPS being available in the EU market.

It is considered to be very unlikely that non-consortium EU FR EPS pellet producers will have *excess* supply of the pFR which would enable them to increase capacity beyond their

[54] 21/08/2015 is the last date whereby HBCDD can be used in the EU unless authorisation is granted

existing output levels. To help justify this, they would have to more than double their sales (and production) to cover the loss of production from consortium members (who account for over 50% of the EU market[55]).

A more plausible outcome is that in the short term non-EU EPS producers will focus on supplying the EU market with FR EPS pellets containing the pFR whilst also making FR EPS containing HBCDD of the pFR to service their existing market outside of the EU (subject to regulatory constraints). The EU could therefore risk losing some of its share of the export market for FR EPS pellets, as well as a situation where a higher volume of FR EPS (pellets with the pFR) is imported into the EU.

EPS formulators located within the EU will either have to shut down operations if there is insufficient supply or (more likely) reduce production at a significant cost (see sub-Section 4.2.2 below). This will have an impact on competitiveness as those with more supply of the pFR will have a competitive advantage over those with insufficient/no supply. This short term competitive advantage could lead to longer term gains in market share (on a per company basis).

Members of the consortium have indicated that the pFR will be more expensive than HBCDD which was also confirmed in the Chemtura (2013)[24] presentation at the October 2013 UNEP meeting. In light of a shortfall in supply (relative to demand) available, pFR is likely to be secured through a price premium, which is undesirable for consumers/society who will incur some of the added cost though a higher cost of FR EPS. This added cost is created by supply constraints rather than necessarily through addressing externalities from FR EPS production (i.e. releases of the substance into the environment) which would be deemed more acceptable (from a policy perspective).

The overall level of FR EPS available in the EU is likely to be reduced further because imports of pellets (containing HBCDD) from outside the EU will also not be permitted without authorisation (for use 2) as it is a mixture (see Section 1.2.3). It is reasonable to assume that, if consortium members located in the EU are refused authorisation for use 1, so will importers located outside the EU (for use 2). If this is not the case, it would put EU companies at a significant competitive disadvantage, even for those EU sites using the pFR, since FR EPS pellets made with HBCDD are likely to be cheaper (given the cost of HBCDD and that less HBCDD than pFR is needed to achieve the required FR standards).

[55] Their exact share of the market is not provided as this is considered to be CBI

Potential market distortion

It is preferable that EU legislation is in line with the global regulatory framework such as the Stockholm Convention which would enable non-EU producers to continue to use HBCDD for building applications (EPS and XPS) until 2019 and possibly a further five years depending on the global supply of the pFR. This would allow EU FR EPS producers to compete on a level playing field with producers outside of the EU.

If authorisation were refused for use 1 (and use 2) it would create a market distortion between the EU market and the rest of the world. Not only would EU formulators of FR EPS be unable to supply the EU market but, a refused authorisation would not allow them to supply the rest of the world. This would put EU formulators at a significant disadvantage with non-EU producers who can continue to supply EPS formulated with HBCDD to the rest of the world.

A refused authorisation raises the potential for non-EU formulators to gain a long term market share as a result of EU formulators not being able to compete in these markets. The extra market share and resulting revenue could potentially also result in these formulators having greater power to negotiate with suppliers of the pFR and other materials over supply and price.

4.2.2 Lost EU sales revenue – EPS formulators and their upstream suppliers

The recommendations in the Sixth Conference of Parties in May 2013 (EC 2013[2]) will mean that HBCDD suppliers are limited to sales for EPS and XPS for building applications which in itself is time-limited. A refused authorisation for use 1 will mean HBCDD suppliers will be further limited to formulators located outside of the EU.

However the impacts on HBCDD sales in the EU to HBCDD suppliers have not been estimated in this SEA as it is believed that these suppliers will switch to supplying the pFR to EPS formulators in the EU market instead of HBCDD. In fact, Great Lakes Solutions-Chemtura Corporation, ICL-Industrial Products and Albemarle (US) have all indicated that they are setting up new plants to make the pFR (See Appendix B).

Pentane, peroxide and styrene suppliers may be more significantly affected by a refused authorisation in the short term. There will still be demand for their products from EPS formulators who have some supply of the pFR but this will be less than currently demanded. An overall reduction in the demand for these materials is therefore expected[56]. Impacts to suppliers have not been separately estimated (to avoid the double-counting economic impacts) as they are already encompassed within the lost sales value for EPS formulators as the sales

[56] If there were excess demand on the market from other sources they (or new suppliers) would have already increased supply to meet this demand.

value to EPS formulators already factors in the cost of raw material as well as returns to capital and wages.

The historical annual value of FR EPS pellet sales for the consortium is estimated to be approximately €0.8 - 1.3 billion per year (See Table 2.17). Table 4.1 shows the estimates of lost sales value to EPS formulators over the period 2016-2019 would be €1,175m in Present Value (PV), if authorisation for use 1 was refused. After this time (beyond 2019), it is hoped that the pFR will become available in sufficient supply to allow FR EPS pellet producers in the consortium to continue operating at normal capacity. The increase in the supply of the pFR in the long terms is, however, not guaranteed (See section 2.3).

Table 4.1 Lost sales value to consortium members (EPS formulators) over 2016-19

	2015	2016	2017	2018	2019	Total	Total (PV)
Lost production (kt)	*Confidential – This was provided in the confidential version to ECHA*						
Lost sales (€million)	270	260	109	0	649	1,288	1,175

Notes:

1. Figures relate to the consortium sales of EPS pellets only rather than the whole EU FR EPS formulation market.
2. Figures are rounded to nearest unit and rounded to larger unit of measure (i.e. kt and €m) to avoid spurious accuracy.
3. The estimated lost values are based on the volume of HBCDD that can no longer be used or be replaced by the pFR given the shortfall in supply as shown in Table 2.12.
4. Present value (PV) has been estimated using a discount rate of 4% as recommended in the ECHA SEA guidance (2011) with a base year of 2015.

The economic impacts presented in Table 4.1 do not account for the *possibility* of consumers switching to an alternative insulation material to FR EPS. This is covered in the “Use 2” assessment (Section 5) because alternatives materials such as mineral wool and XPS are substitutable for EPS articles (i.e. FR EPS boards and blown beads) rather than FR EPS pellets.

As noted in Section 4.2.1, it is *possible* that over the period 2016-19, non-EU EPS producers may focus on supplying the EU market with their available supply of the FR EPS pellets containing the pFR, whilst also making FR EPS containing HBCDD and pFR to service their existing market outside of the EU (subject to regulatory constraints). The EU could therefore risk losing some of its share of the export market for FR EPS pellets, as well as a situation where a higher volume of FR EPS (pellets with the pFR) is imported into the EU.

Therefore, some or all of the lost sales to consortium members (the applicants) shown in Table 4.1 could *potentially* be absorbed by increased imports of FR EPS without EU consumers necessarily having to switch to a different type of insulation material.

Non-EU increased sales revenue is not included within the scope of the SEA since they do not occur within or benefit the EU. The estimates shown in Table 4.1 therefore provide a good (upper bound estimate) of the total loss to the EU from a refused authorisation for use 1. A lower bound estimate would incorporate the fact that there would be some displacement by other insulation materials made in the EU. This is covered in the CBA for use 2 in Section 5.

In practice it could be a combination of greater imports into the EU as well as use of different types of insulation material used in the EU, meaning the best estimate could be somewhere between the low and high bounds of the estimates.

4.3. Environmental impacts

4.3.1 Introduction

The mass-balance shown in Table 2.22 indicates that in total as a reasonable worse-case scenario up to 1.98 tonnes of HBCDD could be released into the environment over a **4 year** period. A total of 84% of the HBCDD that is released is either degraded in the environment within the four year period or removed in sewage treatment (and then incinerated or landfilled). This is the sum of the amount degraded in the environment (1.29 tonnes) and the amount removed by STP (0.37 tonnes), which is a total of 1.66 tonnes, divided by the total release to the environment (1.98 tonnes). Up to 190 kg may be found in freshwater and marine sediment and up to 130 kg found in soil. However, this assessment does not provide an indication of the scale of these releases and the associated impacts to the environment, i.e. it does not indicate geographically where the releases will happen and where geographically the HBCDD will end up.

Therefore, an assessment of environmental impacts for this application for authorisation has been undertaken to provide an indication of the possible effects of the continued use of HBCDD at exposure levels in the environment for the proposed authorisation period (i.e. four years).

The assessments of environmental exposure done for REACH registration dossiers assumes *constant* releases[57], to the environment from all uses of the substance. However to understand the possible impacts within the authorisation situation there is a need to understand the relative *contribution* that EPS use (for a limited tonnage from the applicants of this dossier) makes to the environment burden of the substance. This assessment therefore needs to take into account only the EPS use and also the amount of HBCDD (from all uses) that is already in the environment and how that will change over time.

The specific contribution of FR EPS use in the formulation of EPS pellets, the manufacturer of FR EPS articles and the use of those articles (service life) is considered in detail in the report “HBCDD: Modelling of concentrations in sediment and soil over time” (PFA 2013, see

[57] Intermittent releases can also be assumed, but in this case and with continuous releases a steady-state equilibrium distribution of the substance between different environment compartments (i.e. water, sediment, soil and air) is assumed.

Appendix F). The study considered the amount of HBCDD in specific environmental compartments both in terms of the amount existing in the environment and the additional contribution from EPS formulation and use for four additional years. It takes into account the breakdown of HBCDD in the environment (i.e. how long it takes for HBCDD to degrade in soil and sediment) and compares the situation with and without four additional years of EPS manufacture and use at local, regional and continental scales.

The approach to the assessment of environmental impacts is based on understanding environmental exposure to HBCDD in comparison to levels at which effects may be manifested. The approach taken in conventional risk assessment (e.g. to assess adequate control for a chemicals safety assessment and to report in a chemical safety report for a REACH registration dossier) is to compare the level at which no effects are expected with environmental concentrations and to derive a risk characterisation ratio to determine if there is a risk or not. However, since HBCDD is a PBT it is not possible to establish a no-effects level for environmental effects and thus this assessment cannot take the same approach.

Rather than compare environment levels with a predicted no effect concentration (PNEC), the levels found in environmental compartments are modelled in much more detail and the characteristics of these levels is described over time. Environmental levels can then be compared with a number of effects levels that can be found from other studies to understand the possibility of effects at the levels in the environment where EPS use is responsible. In addition, although it is not possible (in the context of assessing a PBT in REACH) to indicate a safe level of HBCDD, it is possible to indicate a level which low enough for no effects to be reported and/or reasonably expected.

Using the detailed modelling it is also possible to indicate, for any given level of HBCDD in the environment, the time needed to get to exposure levels if there was no use of HBCDD after a certain point (i.e. the sunset date) and the additional time it would take to get to exposure levels if there were 4 more years of HBCDD use in EPS. Therefore, irrespective of what one might consider to be a 'safe level', it is possible to compare the 'impact' in terms of an additional environmental burden that the time-limited continued (i.e. additional) use of HBCDD would create.

4.3.2 Levels predicted in the environment – modelling HBCDD concentrations in the environment over time

In the PFA (2013) study (see Appendix F) detailed consideration is given to understanding the concentrations of HBCDD that will end up in the environment under the continued use and non-use scenarios. The following considerations are accounted for in the approach used to model environmental concentrations:

- The decline of the substance in the environment over time; and
- The amount of the substance in the environment to start with (i.e. from all uses).

The assessment assumes only that EPS use will continue after the sunset date and allows for the estimation of:

- The additional amount of HBCDD that continued EPS use will contribute, and
- The concentrations of HBCDD in the environment over time.

The key inputs to the model are:

- The amount of use of the substance;
- The controls on releases;
- The degradation rate of the substance (especially in the compartment where HBCDD mostly ends up); and
- The amount of HBCDD already in the environment.

Data for the substance properties was, as with the CSR, from public sources (i.e. the EU Risk Assessment Report for HBCDD). The inputs to the model were calculated using reasonable worst-case tonnage estimates and releases. A mathematical model was derived and applied in order to estimate the change in concentration in the environment (with a focus on aquatic (both marine and freshwater) sediment and soil, since this is where HBCDD ends up in the environment).

Changes in concentrations in the environment over time are calculated using the degradation constant for the substance in sediment and in soil. This allows for the comparison of the non-use and continued use scenarios.

Modelling is carried out at the following spatial scales:

- Continental – in modelling terms this is the concentration in a remote area;
- Regional – this is the background concentration in a theoretical country in which the process happens; and
- Local – this is in the close vicinity to a site were the process happens.

The use patterns of HBCDD in the manufacture of EPS by formulators (use 1) and the manufacture of EPS articles (use 2) were considered together since the use patterns of both uses are so closely linked. The modelling of environmental impacts also looked at the service life of EPS separately. Results are summarised below for sediment and then soil at continental, regional and local scales.

<u>Note on units and scale used in the environmental modelling results.</u>

In sediment and soil the standard and accepted way to express concentration is as the weight of substance per unit weight of soil or sediment. Since soil and sediment contain water the weight of substance per unit weight of soil or sediment is greatly affected by whether the soil or sediment is reported as wet weight (ww) or dry weight (dw), i.e. with or without water.

For this assessment we have reported soil and sediment as dry weight. The standard way to report the loading of sediment or soil with the substance is as milligrams (mg) or micrograms (µg) per kilogram (kg) of soil or sediment. Because such low levels are reported here we report the scale in terms of fractions of micrograms. The axis labels on the graphs presented indicate the scientific notation for that with '1.00 E-01' meaning 0.1 µg and 1.00 E-02 meaning 0.01 µg and so on. It may help understanding to think of the concentrations in terms of parts of substance per part of soil or sediment. In this way 1 µg per kg is 1 part per billion (ppb). A nanogram (ng) is one thousandth of a microgram and therefore reporting 20 ng/kg can be expressed as 20 parts per trillion.

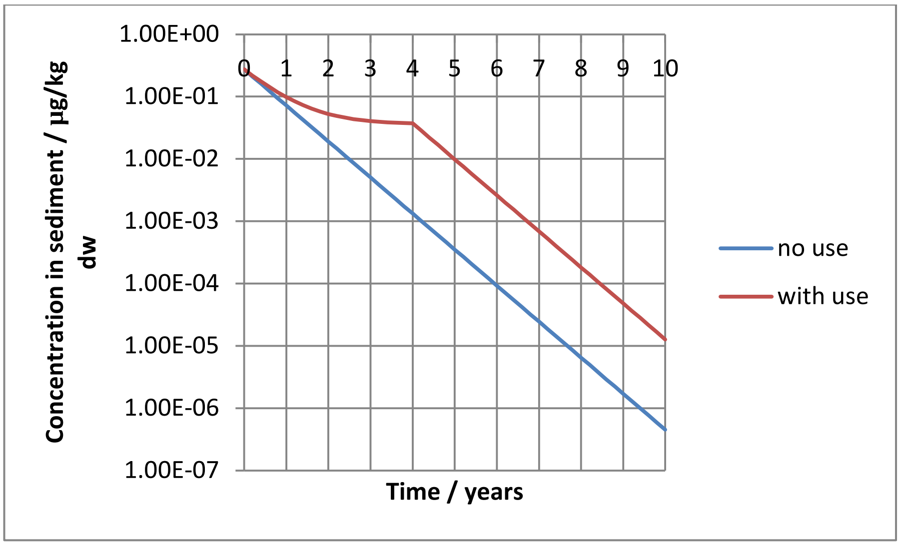
Continental scale (sediment and soil)

The results of the modelling are shown in Figures 4.1 and 4.2 below. The comparison of the 'no use' scenario (blue line) with the 'with EPS use' scenario (red line) shows how the continued use of HBCDD in EPS would impact the concentration in freshwater sediment at the continental scale. Modelling at this spatial scale is intended to model a reasonable worst-case for remote locations.

Figure 4.1 shows the concentration in sediment (on the y-axis) plotted against time (on the x-axis). Only a small difference between the sediment concentrations for the two scenarios is observed. The 'with EPS use' scenario line runs very close to the 'no use' scenario for the first two years. An increase in concentration for 'with EPS use' compared to 'no use' is then observed. However, it should be noted that, within 1 year, the concentrations in sediment fall to 0.1 µg / kg dwt, even for the 'with EPS use' scenario. This is a very low concentration, around the limit of detection (which is approximately 0.1 µg / kg dwt or higher in monitoring studies quoted in the RAR).

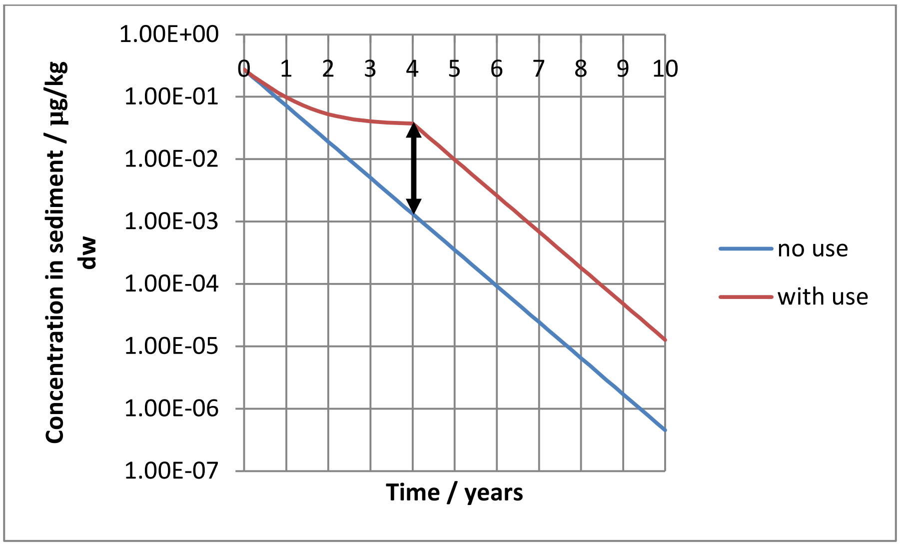
After four years, the use of HBCDD in EPS is assumed to stop and the 'with EPS use' line runs parallel to the 'no use' line as both lines are governed only by the same first-order degradation process.

Figure 4.1 Concentration of HBCDD in sediment over time, continental scale (logarithmic y-axis)



The increase in concentration of HBCDD after four years is 0.035 µg / kg dwt (35 ng / kg dwt). This is illustrated above in Figure 4.1. When multiplied by the mass of sediment in the continent, this is a total of 28 kg of HBCDD.

Figure 4.2 Concentration of HBCDD in sediment over time, continental scale (logarithmic y-axis), with additional concentration resulting from EPS use marked (black arrow)



The assumption with the degradation process is that the concentration of a substance halves during each half-life period and, therefore, diminishes over time but never reaches zero. It is, however, informative to define a concentration at which the concentration in sediment can be said to be effectively zero. For illustrative purposes, a concentration of 0.001 µg / kg dwt (1 ng / kg dwt) is used here. The time taken for this level to be reached in the 'no use' scenario is 4.2 years; the time taken for this level to be reach in the 'with EPS use' scenario is 6.7 years. Therefore, the additional time for HBCDD concentrations to reach negligible levels in the ‘with EPS use’ scenario is 2.5 years. This is illustrated in Figure 4.3 below. It should be noted that the actual level selected to represent ‘negligible’ is not important (as long as it is less than or equal to the no use concentration at 4 years), because after 4 years the ‘with EPS use’ and ‘no use’ concentrations decrease at the same rate.

Figure 4.3 Concentration of HBCDD in sediment over time, continental scale (logarithmic y-axis), with additional time taken to reach negligible concentration marked (black arrow)

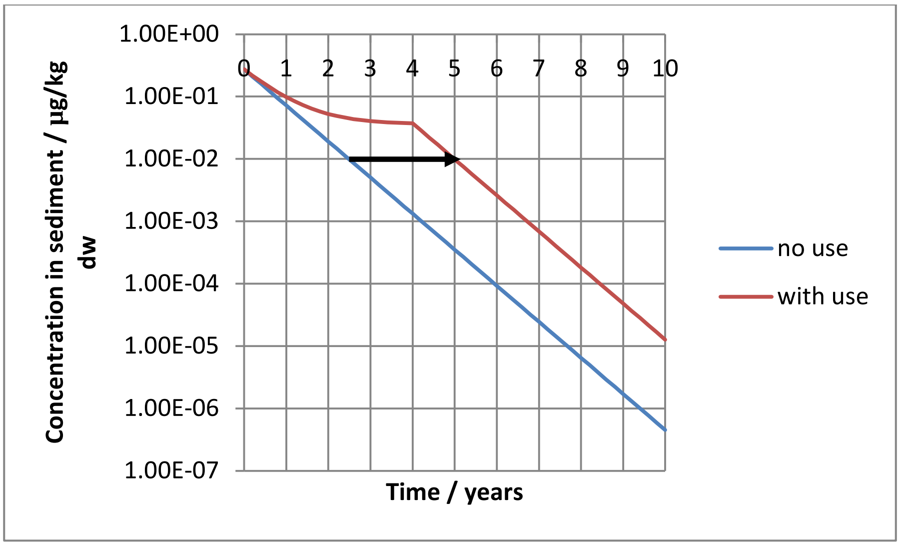
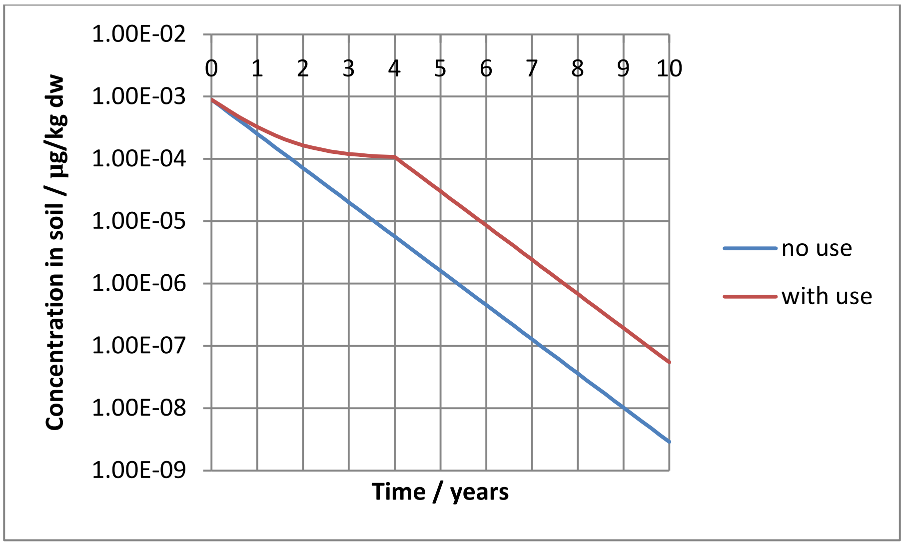


Figure 4.4 below shows the concentration in soil (on the y-axis) plotted against time (on the x-axis). In a similar way to the modelling for sediment, only a small difference between the soil concentrations for the two scenarios is observed. The ‘with EPS use’ scenario line runs very close to the ‘no use’ scenario for the first two years. An increase in concentration for ‘with EPS use’ compared to ‘no use’ is then observed. However, it should be noted that the concentrations in soil are below 0.001 µg / kg dwt even for the ‘with EPS use’ scenario. This is a very low concentration, likely to be well below limits of detection (which are around 0.1 µg / kg dwt or higher in monitoring studies for sediment quoted in the RAR).

After four years, the use of HBCDD in EPS is assumed to stop and the ‘with EPS use’ line runs parallel to the ‘no use’ line as both lines are governed only by the same degradation process.

Figure 4.4 Concentration of HBCDD in soil over time, continental scale (logarithmic y-axis)



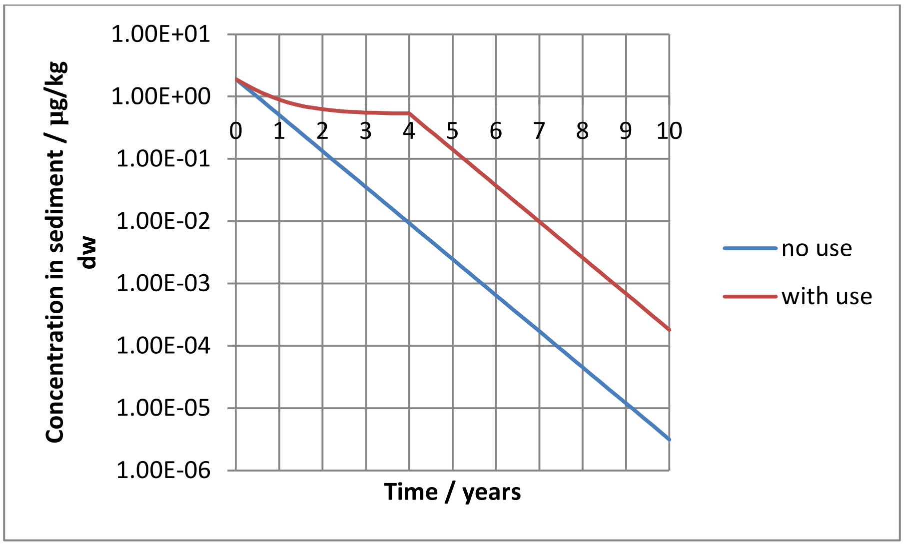
The increase in concentration of HBCDD after 4 years, is 0.0001 µg / kg dwt (0.1 ng / kg dwt). When multiplied by the mass of soil in the continent, this is a total of 64 kg of HBCDD. The additional time for HBCDD concentrations to reach negligible levels in the 'with EPS use' scenario is 2.3 years

Regional scale

Figure 4.5.shows the concentration in sediment (on the y-axis) plotted against time (on the x-axis). Only a small difference between the sediment concentrations for the two scenarios is observed. As with the continental scale, it can be seen that the 'with EPS use' scenario line runs very close to the 'no use' scenario for the first year. An increase in concentration for 'with EPS use' compared to 'no use' is then observed. However, it should be noted that within 1 year, the concentrations in sediment have fallen to less than 1 µg / kg dwt even for the 'with EPS use' scenario. This is a very low concentration.

After four years, the use of HBCDD in EPS is assumed to stop and the 'with EPS use' line runs parallel to the 'no use' line as both lines are governed degradation process.

Figure 4.5 Concentration of HBCDD in sediment over time, regional scale (logarithmic y-axis)



The increase in concentration of HBCDD after four years is 0.5 µg / kg dwt. When multiplied by the mass of sediment in the region, this is a total of 5 kg of HBCDD.

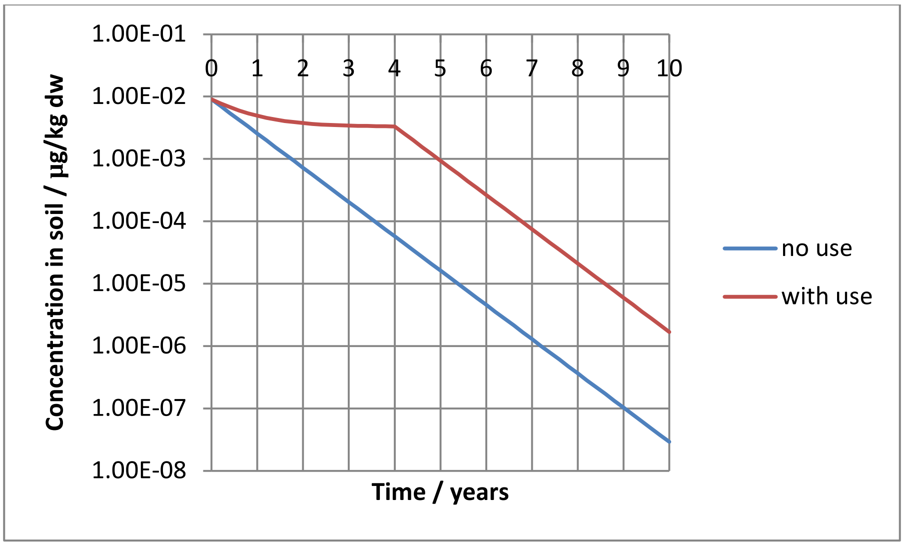
The concentration of a substance halves during each half-life period and, therefore, diminishes over time but never reaches zero. It is informative, however, to define a concentration of HBCDD at which the concentration in sediment can be said to be effectively zero. For illustrative purposes, a concentration of 0.001 µg / kg dwt (1 ng / kg dwt) is used here. The additional time for HBCDD concentrations to reach negligible levels in the 'with EPS use' scenario is three years. Note that compared to the continental scale that the time taken to reach this level is longer; this is because the concentration at continental scale is lower than at regional scale, (given the same decay rates the lower the concentration is the sooner it will reach a particular level). It should also be noted that the actual level selected to represent 'negligible' is not important (as long as it is less than or equal to the no use concentration at four years), because after four years the 'with EPS use' and 'no use' concentrations decrease at the same rate.

<u>Regional scale soil</u>

Figure 4.6 shows the concentration of HBCDD in soil (on the y-axis) plotted against time (on the x-axis). Only a small difference between the soil concentrations for the two scenarios is observed. It can be seen that the 'with EPS use' scenario line runs very close to the 'no use' scenario for the first year. An increase in concentration for 'with EPS use' compared to 'no use' is then observed. However, it should be noted that the concentrations in soil are below 0.01 µg / kg dwt even for the 'with EPS use' scenario. This is a very low concentration, likely to be below limits of detection (which are around 0.1 µg / kg dwt or higher in monitoring studies for sediment quoted in the RAR).

After four years, the use of HBCDD in EPS is assumed to stop and the ‘with EPS use’ line runs parallel to the ‘no use’ line as both lines are governed only by the same degradation process.

Figure 4.6 Concentration of HBCDD in soil over time, regional scale (logarithmic y-axis)



The increase in concentration of HBCDD after 4 years is 0.003 µg / kg dwt (3 ng / kg dwt). The additional time for HBCDD concentrations to reach negligible levels in the ‘with EPS use’ scenario is 3.2 years

Local scale - sediment

Figure 4.7 shows the concentration in sediment (on the y axis) plotted against time (on the x axis); only a small difference between the sediment concentrations for the two scenarios is observed. It can be seen that, on a local scale, the continued use of EPS does significantly impact the concentrations in sediment over the four year period. This is because the main contribution to the local concentration is the local use of HBCDD in EPS manufacture, and this continues. A point to note is that the graphs show an initial increase in concentration of HBCDD at local scale. This is an artefact of the modelling; in order to set the model, estimates of environment concentration from available measured (monitoring) were used to account for historical amounts in the environment. An underestimation of the amount already in the environment means that the model shows some time for the concentration of the substance to reach a steady state from local emissions (with the contribution of the regional background concentration). In reality, it is likely that the local scale would already be at a steady-state (i.e. concentrations of HBCDD would have reach equilibrium) from the input of EPS formulation in preceding years.

After four years, the use of HBCDD in EPS is assumed to stop and the ‘with EPS use’ line runs parallel to the ‘no use’ line as both lines are governed only by the same first-order degradation process.

The precise shapes of these curves are very sensitive to variations in the model inputs. The overall conclusions is that, in the ‘with EPS use’ scenario, the concentration of HBCDD in local sediment remains at the same order of magnitude as that already present (an increase or decrease within this range is possible). The continued use of EPS may therefore have an adverse impact on the environment close to the sites where EPS is manufactured. After the four years, the concentration of HBCDD falls rapidly (see Figure 4.8).

Figure 4.7 Concentration of HBCDD in sediment over time, local scale (linear y-axis)

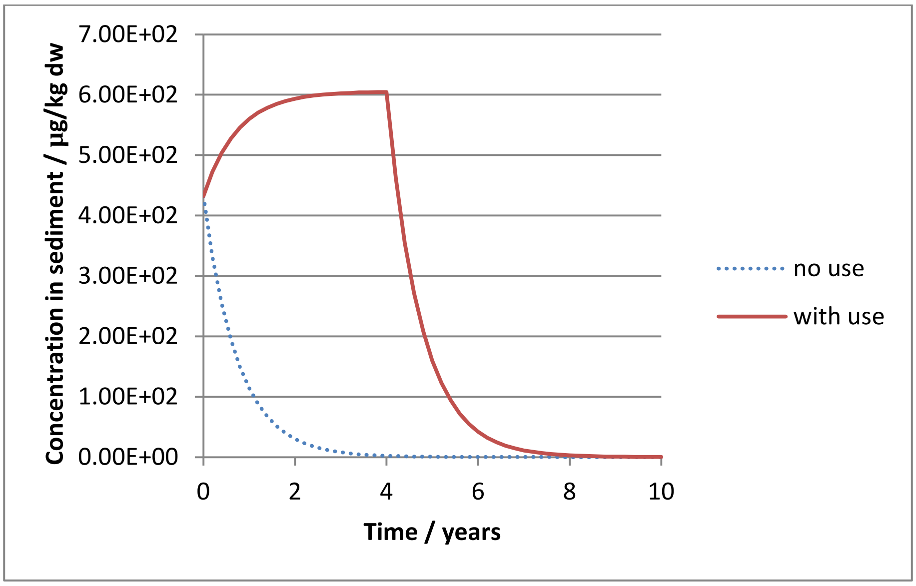
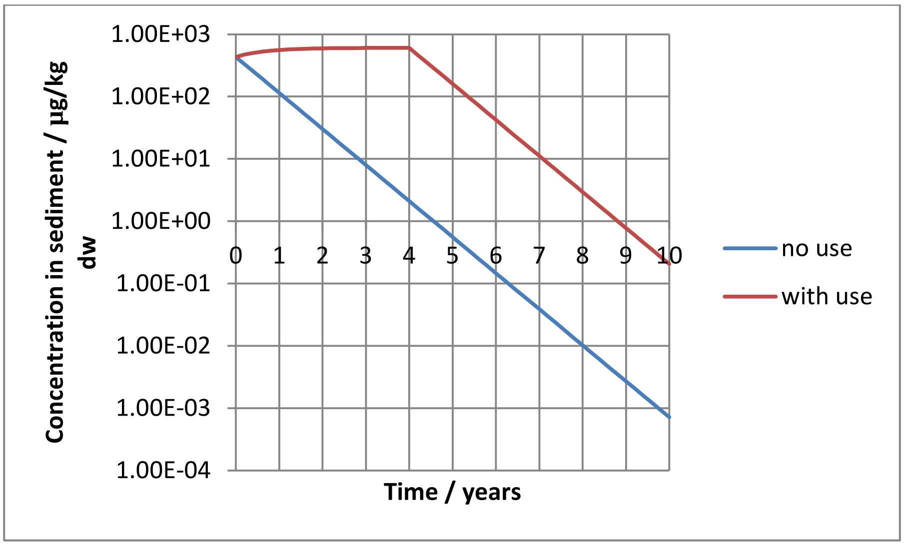


Figure 4.8 Concentration of HBCDD in sediment over time, local scale (logarithmic y-axis)



The difference in concentration of HBCDD after 4 years is 590 µg / kg dwt. The additional time for HBCDD concentrations to reach negligible levels in the 'with EPS use' scenario is 4.2 years.

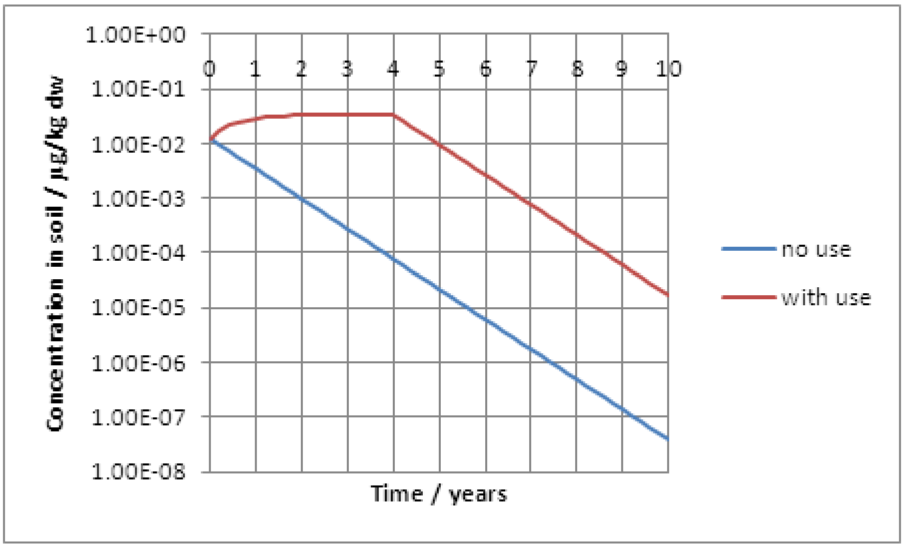
<u>Local scale soil</u>

Figure 4.9 shows the concentration in soil (on the y axis) plotted against time (on the x axis). Only a small difference between the soil concentrations for the two scenarios is observed. It can be seen that, on a local scale, the continued use of EPS does significantly impact the concentrations in soil over the 4-year period. This is because the contribution made to the local concentration is the local use of HBCDD in EPS manufacture, and this continues.

After four years, the use of HBCDD in EPS is assumed to stop and the ‘with EPS use’ line runs parallel to the ‘no use’ line as both lines are governed only by the same degradation process.

The precise shapes of these curves are very sensitive to variations in the model inputs. What can be understood is that, in the ‘with EPS use’ scenario, the concentration of HBCDD in local soil remains at the same order of magnitude as that already present (an increase or decrease within this range is possible). The continued use of EPS may therefore have an adverse impact on the environment close to the sites where EPS is manufactured. After the 4 years, the concentration of HBCDD falls rapidly.

Figure 4.9 Concentration of HBCDD in soil over time, local scale (logarithmic y-axis)



The increase in concentration of HBCDD after 4 years is 0.035 µg / kg dwt. The additional time for HBCDD concentrations to reach negligible levels in the ‘with EPS use’ scenario is 4.8 years.

<u>Service life</u>

The use of HBCDD in EPS in each of the last 25 years was calculated assuming a linear increase over this period to reach the 2014 level of 8000 tpa. This gave an estimate for use in the year 2000 which was comparable to that quoted in the EU RAR (EC 2008). The use of HBCDD in XPS, HIPs and textiles was considered to follow the same trends over this period with the ratios of use of EPS, XPS, HIPS and textiles remaining constant compared to those in the RAR (1:0.5:0.06:0.3). The expected release over each year from 2014 to the end of the service life of these articles was then calculated.

In addition, the ‘with EPS use’ scenario included use of HBCDD in EPS at 8000 tpa from 2014-2018.

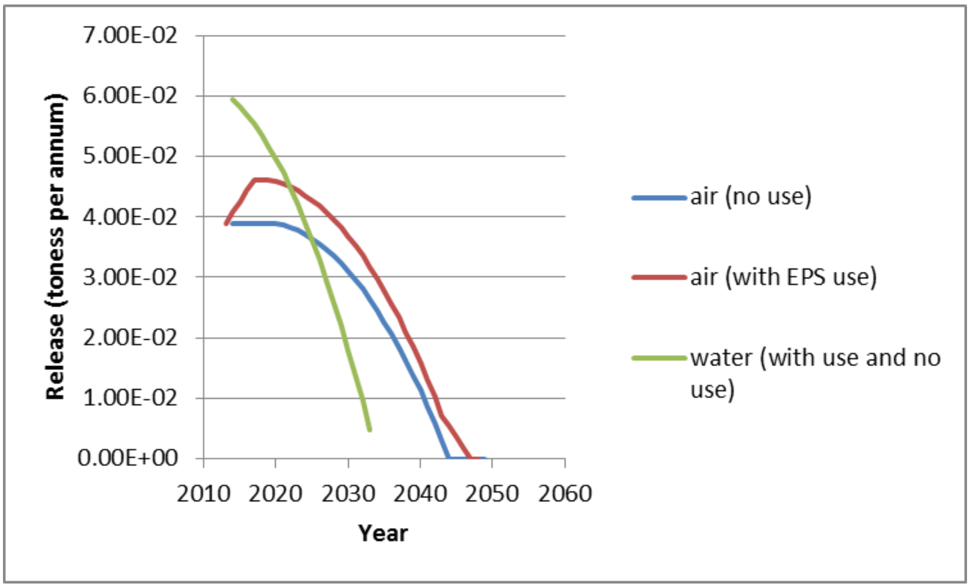
The releases are shown in Figure 4.11. Release to air is from plastics; releases to water are from textiles.

Figure 4.10 takes into consideration all uses in plastics and textiles and the releases from service life into the future based on the ratio of volume used in terms of HBCDD. Assuming that all uses would stop from the sunset date, there would still be releases for all these uses due to the continued service life for some years to come – assumed to be 25 years (this was a concern raised in the EU RAR). It can only be assumed that the EPS use will continue after the sunset date, since that is the subject of this authorisation application, it cannot be assumed that any other use will continue.

Considering the releases to air from plastics and textiles in service, but with no further HBCDD containing products coming onto the EU market after the sunset date: The blue line on the plot in Figure 4.11 shows how the releases will decrease over time, starting at around 40 kg per annum. Considering the release to air again, but this time with only EPS use continuing for four years beyond the sunset date (red line on the plot), it can be seen that there is an increase and then a subsequent decline following a similar trajectory as no for no-use[58]. Considering the releases to water (green line in Figure 4.11) there is no difference at this scale between continued EPS use for four years and no use at all. This is because the uses that dominate releases to water are uses other than EPS (e.g. textiles); the main release from EPS in service life is to air. The consequences of this in terms of the concentrations in sediment and soil are shown in Figures 4.11-14.

[58] The apparent initial increase in concentration shown in the ‘with-use’ curve compared to the ‘no-use’ curve is an artefact of the way that the modelling was set up. In order to set the model with a concentration in the environment representative of all historical uses, the concentration remaining in the environment was informed by data reporting measured concentrations (i.e. this was used to set the background concentrations). The continued use (‘with-use’) then contributes to that concentration and therefore shows an initial increase.

Figure 4.10 Releases of HBCDD from articles



In order to incorporate this use pattern into the model, the releases were spread evenly over either 20 years or four years, maintaining the same total release. The results are shown graphically in Figures 4.11-4.14. The modelling was done on the continental scale as use of articles containing EPS is widely dispersed across Europe.

Figure 4.11 Concentrations in continental sediment; releases from service life spread over 20 years

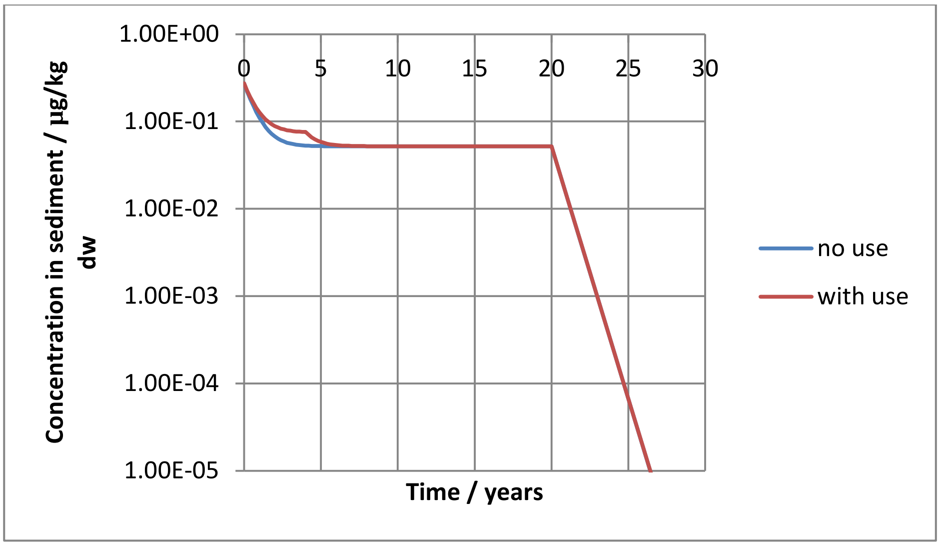


Figure 4.12 Concentrations in continental sediment; releases from service life spread over 4 years

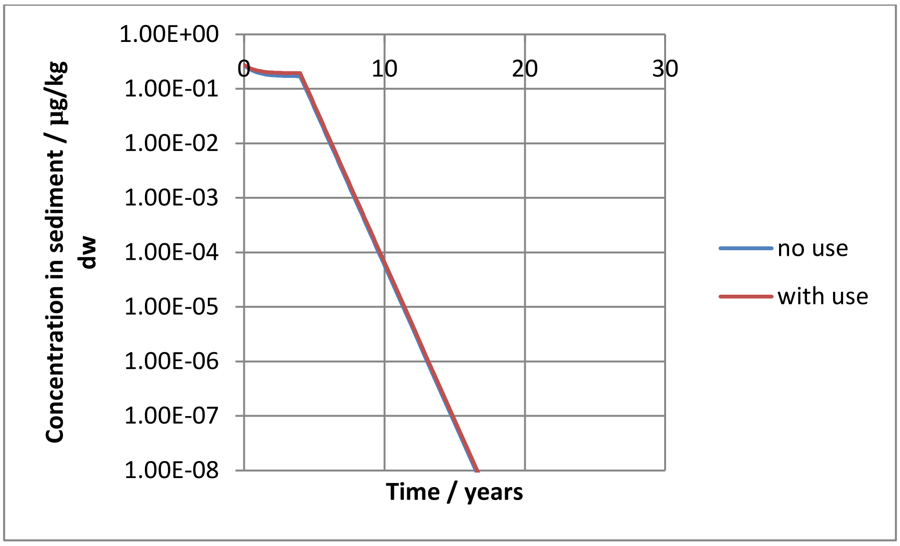


Figure 4.13 Concentrations in continental soil; releases from service life spread over 20 years

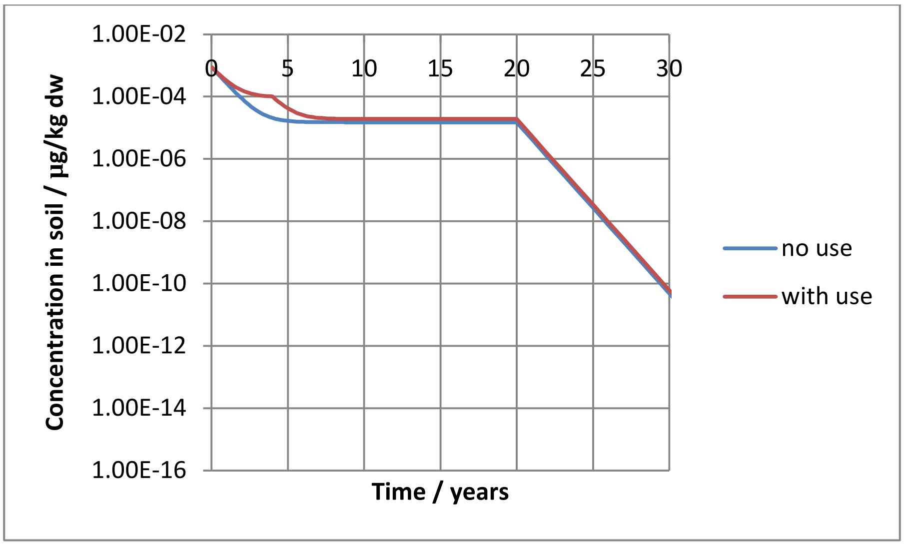
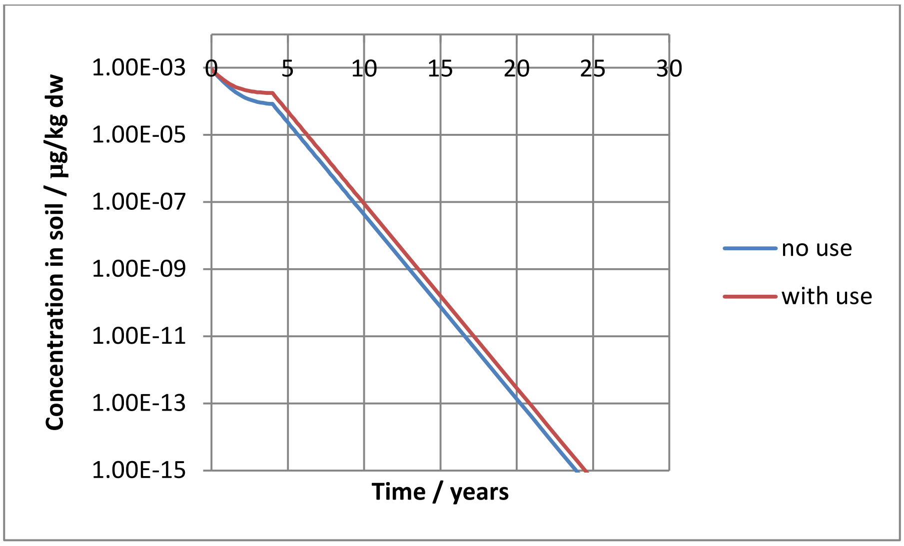


Figure 4.14 Concentrations in continental soil; releases from service life spread over 4 years



The sudden decrease in concentrations after four years in Figures 4.12 and 4.14.and after 20 years in Figures 4.11 and 4.13 is an artefact of the way the releases are spread evenly over these periods. In reality the changes in concentration would be more gradual. However, it is reassuring to note the patterns shown in the 4 year and 20 year graphs are very similar, i.e. that the additional contribution of FR EPS made during the four years authorisation period make little difference to the overall concentrations in soil or sediment regardless if whether it is assumed that this amount is added over a four year or 20 year period.

The graphs for sediment (Figures 4.12 and 4.13) both show similarities between the 'with EPS use' scenario and the 'no use' scenario. This is because on-going releases to water (and then to sediment) are dominated by the releases to water resulting from textile articles. Both scenarios show a decreasing concentration of HBCDD over time. The additional time to reach negligible concentrations is approximately 0.1 years and the additional concentration of HBCDD at the end of the release period in the 'with EPS use' scenario is 0.02 µg/kg sediment dw. These figures are not dependent on the period over which releases are spread (4 years or 20 years).

The graphs for soil (Figures 4.14 and 4.15) both show similarities between the 'with EPS use' and the 'no use' scenario. . This is because on-going releases to air (and then largely to soil) from new EPS articles are about 25% of the releases to air from existing articles. Both scenarios show a decreasing concentration of HBCDD over time. The additional time to reach negligible concentrations is approximately 0.2 years in the 20 year model and approximately 0.5 years in the 4 year model. The additional concentration of HBCDD at the end of the release period in the 'with EPS use' scenario is 0.00008 µg/kg sediment dw in the 20-year model and 0.00009 µg/kg sediment dw in the 4 year model.

Conclusions on environmental exposure

The continued use of HBCDD in EPS for 4 years would result in a worst-case total use of HBCDD 32,000 tonnes. More than 99% of this would be incorporated into EPS articles and remain there at the end of their service life (after demolition). A total of 1.98 tonnes of HBCDD would be released to air or wastewater. An estimated 84% of this release would be either degraded in the environment within the 4-year period or removed in sewage treatment (and then incinerated or landfilled). It is estimated that 180 kg of HBCDD would be found in freshwater and marine sediment and 130 kg would be found in soil.

Initial modelling took into account releases from the manufacture of HBCDD, and formulation, conversion and cutting of EPS. On the continental scale (representing a worst-case for remote locations), differences between the 'with EPS use' and 'no-use' scenarios are small and both absolute concentrations and increases in concentrations from the 'with EPS use' scenario are small. On the local scale (representing an area within a few kilometres of an EPS formulation site), continued use of HBCDD concentrations in solid and sediment remain at current predicted concentrations for the duration of application period (since the emissions from EPS formulation sites will dominate HBCDD releases at these locations) and decrease only after use of HBCDD ceases. As expected the picture for regional scale is in between these local and continental scales. However, recovery of the environment (as measured by additional time to reach an arbitrary negligible level) takes only a few years for all scales.

When releases over the service life of articles are taken into account, the differences between the use and no-use scenarios are reduced when only service life is considered (since releases of HBCDD from service life is limited). The absolute amount of HBCDD added to the environment from the service life of EPS articles from four additional years' use of HBCDD are increased by an amount of 230 kg, which represent about 15% increase in releases from service life, compared to no use of EPS after the sunset date.

Possible impacts from continued use of HBCDD

As mentioned at the beginning of this section, the assessment of impacts can be based on an estimation of the contribution of the continued EPS use to the amounts of HBCDD in the environment, in terms of total load and concentrations. We have set out from estimation concentrations using models of the environment that these change over spatial scale and over time. For a PBT substance, the assessment cannot compare exposure concentrations to no effect concentrations to show that specific uses are safe. Therefore, an assessment of the impacts based on estimation of exposure alone should be sufficient. This will indicate what happens in terms of environmental concentrations of the substance with continued use compared to a prohibition on all uses. In this manner it is possible to compare the amounts getting into the environment from continued use and how long it would take to reach the same concentration level after a cessation of all uses.

Others have taken a different approach to the assessment of impacts. There are two notable studies that put forward methodologies for the assessment of environment impacts, both of which used HBCDD as case studies. The Netherland's RIVM (2012)[59] report put forward a methodology based on ranking of PBTs. This was used to compare HBCDD with the two substance alternatives[60]. The method is useful for comparing substances in terms of PBT profile, but does not give an absolute indication of the environmental impacts of a substance (see also SCRAM assessment below by RPA).

In RIVM (2013), the PBT ranking method indicated a lower score for the substitution substances compared to HCBDD. However, the hazard data on the alternatives and HBCDD were considered to be insufficient. In addition, risks derived from the risk characterisation ratios (RCRs) were converted into impacts by deriving the Percentage Affected Species (PAFs). In order to derive the PAFs, environmental concentrations and hazard data were combined: the equation for the PAF uses regional Predicted Environmental Concentration (PEC) and the average toxicity of the substance. The aquatic PECs for the life cycle of HBCDD in the continued use scenario and the aquatic PECs for the alternatives were calculated. The average toxicity of the substance was calculated using model predictions (ECOSAR). The PAFs were then combined and the values used to indicate whether the alternatives provided a lower impact. In this case, the alternatives did provide a lower impact. The authors comment that both the PECs and the PAFs for HBCDD and its alternatives are quite low. For HBCDD the calculated regional PAF is 0.16% for all applications and across its entire life cycle. Both the PBT ranking method and the PAF compare the use of alternatives to HBCDD. The choice of alternatives and the end use release estimation were the major sources of uncertainty identified in the assessment, followed by the lack of hazard data.

In the EC (2011) report[61], the authors propose a framework for assessing impacts which includes case studies involving the use of HBCDD. For environmental impacts, the framework proposed going from qualitative descriptions of possible environmental impacts, through to semi-quantitative and quantitative descriptions of impacts. The authors considered it appropriate to apply benchmarking techniques to compare the substances to others assigned

[59] (RIVM 2012) "*From risk assessment to environmental impact assessment of chemical substances Methodology development to be used in socio-economic analysis for REACH*"

[60] Two Policy Scenarios in the RIVM report assumed the replacement of HBCDD with other flame retardant, namley dibromoethyldibromo-cyclohexane and tris(2-chloroethyl)phosphate. Neither of these substances is specifically mentioned as possible alternatives in the AoA. The AoA mentions 1,2-dibromo-4-(1,2-dibromoethyl)cyclohexane (CAS 3322-93-8), which is potentially persistent and bioaccumulative, although the RIVM study notes a lack of data on dibromoethyldibromo-cyclohexane. Halogenated phosphates such as tris(2,3-dibromopropyl)phosphate (CAS 126-72-7) are mentioned in the AoA, but phosphate compounds are not considered to be technically feasible alternatives for EPS. It should be noted that the RIVM study was a theoretical study to investigate the possibilities of assessing different possible policy scenarios and alternative selection did not appear to be based on an in depth analysis in that study.

[61] (EC 2011) - "*Assessing the Health and Environmental Impacts in the Context of Socio-economic Analysis Under REACH Part 2: The Proposed Logic Framework And Supporting Case Studies*" done by RPA for the European Commission

PBT status. The Chemical Scoring and Ranking Assessment Model (SCRAM) were then applied to ‘rank’ various chemicals based on their physico-chemical properties. In the ranking, HBCDD was placed above mercury and PBBs, but below the fungicide hexachlorobenzene, a suspected human carcinogen and aquatic toxicant. Substances with different properties and life cycles are being compared in the ranking system, which is an obvious limitation. For example, the resulting composite SCRAM score of HBCDD placed it above mercury. However, mercury is an element with a well-known, definite cycle and it will not degrade at all.

In addition, a series of dose-response quantifications were attempted: a method based on species sensitivity distributions (SSD) and life cycle impact assessment (LCIA) and their relation to Environmental Quality Standards (EQS) was used. The SSD modelling incorporated sediment data and derived additional NOECs based on algal toxicity data.

The authors attempted deriving an SSD that was compliant with the methods set out in the Technical Guidance Document (TGD - requiring at least ten long-term NOECs from across eight taxonomic groups). There were insufficient data available on HBCDD to derive a TGD compliant SSD (three NOECs across three taxonomic groups).

For the purpose of the case study additional NOECs were generated by extrapolation regression techniques from the toxicity values available in the EU RAR on algae and diatoms to generate no effect concentrations. These levels were assumed to be equivalent to the lowest effect level (LOEC) and a no effect level (NOEC) was generated based on the NOEC/LOEC ratio established in the RAR. Including these additional data points, still only six NOECs from three taxonomic groups were available. The authors concluded that additional data should be generated to derive a more accurate and compliant SSD, but that for the illustrative purposes of the case study an SSD would be generated.

From this data set the fraction affected (y-axis), the lowest log (NOEC) was taken to be: 1/6 (total number of NOEC values used)/2 = 16.7% = 8.3%

A normal distribution was fitted to the log of the toxicity data and the SSD modelling indicated that the HC5 (hazardous concentration for 5% of the species) obtained from the curve was 0.43 µg/l.

Once the SSD curve had been obtained, the values were compared to environmental concentrations. The RAR contains surface water sample data from limited sites, in particular multiple samples close to two production sites, one in the UK and the Netherlands. Ideally monitoring data from a range of sites would be available. A lognormal probabilistic distribution was fitted to the monitoring data and combined to the SSD data graphically. The authors were able to derive a ‘worst-case’ estimate of the percentage of rivers that would exceed the NOEC for 5% of the species (i.e. >0.43 µg/l): 19.3% of European rivers. The estimate of rivers that are likely to be at risk is likely to be conservative due to the monitoring data used.

In the RIVM (2013) report, the authors also converted the sediment data into aquatic toxicity data in order to obtain further data on additional taxonomic groups and derive an alternative

SSD. The HC5 (hazardous concentration for 5% of the species) using this method was 0.52 µg/l.

The authors acknowledge that the HC5 criteria, 5% of the species affected, is simply reflecting a conventional value used in ecotoxicology. The value does not indicate which species might be affected. Furthermore, 5% species loss might be tolerated by some ecosystem but not others.

Dose-response data for the most sensitive aquatic species was used to derive EC_1, $EC_{2.5}$ and EC_5 values and compared to environmental concentrations. This method however only covers one species. Using the *Daphnia magna* data an EC_1 value of 3.9 µg/l was derived. Comparing the EC_1 value to the SSD HC_5 values of 0.43 or 0.52 µg/l gives an indication of the relative sensitivity of the two methods.

Mammalian dose-response data was also used to estimate secondary poisoning impacts to mammals, however there were too many uncertainties associated with the method.

It is clear that the RIVM (2012) and the EC (2011) reports did not have precisely the same objective as this assessment and were more directed at enabling regulatory authorities to understand and prioritise action on substances by understanding impact. Nevertheless, these studies do reflect the difficulty in deriving meaningful impacts without just re-inventing a different set of predicted no effect levels (PNEC) with which to compare estimated and measured exposure. That said it is possible to set out values for effect taken from the literature and compare them to the concentrations that would result from continued use of HBCDD in EPS. Rather than a reinvention of a PEC/PNEC comparison, it is an attempt at indicating on a scale of possible effects where the exposure levels are and thus in a qualitative way indicating the possible severity of effects/impacts. One problem indicated also by other authors is the lack of data on effects and a common unit for expressing toxicity (given that exposure in different environmental media leads to reporting effects data in different units – for water or for sediment or soil for example). It is possible using standard calculations to convert all concentrations to sediment values for example, that way effects can be compared to the levels that might be found in sediment (see box below).

Converting aquatic effects values to sediment concentrations

In order to compare the available sediment and the aquatic toxicity data, the aquatic data was converted into mg/kg. This was achieved by applying the Equilibrium Partitioning Model (EPM) in ECHA 2008, R.10. It should be noted that this method is applied only to enable comparison of relative values for toxicity of HBCDD. Since sediment is the compartment of concern and there are a limited number of toxicity values, non-sediment values have been converted to sediment values using the EPM model. This is different from the application of this method to derive PNEC values for example in a CSA, in which assessment factors are also applied. We are not driving PNEC values here but simply converting already derived values to the ‘common currency’ of sediment concentrations. Nevertheless the values derived should be treated with caution.

This is the same approach used by RPA when transforming sediment data into aquatic toxicity units. The EPM equation R.10-2 (ECHA 2008) is:

$$PNEC_{sediment(freshwater)} = \frac{K_{susp\text{-}water}}{RHO_{susp}} * PNEC_{aqua(freshwater)} * 1000$$

Where:

RHOsusp: Bulk density of wet suspended matter [kg.m^{-3}] = 1150

PNECwater: Predicted No Effect Concentration in water [mg.l^{-1}]

PNECsed: Predicted No Effect Concentration in sediment [mg.kg^{-1} of wet sediment]

Ksusp-water: Partition coefficient suspended matter water [m3.m^{-3}].

Using the parameters described in equation R.16-6 (ECHA 2010, R.16) of the REACH guidance Ksusp-water has been estimated to be 1.08*103 m/m3.

Therefore, the NOEC or effect levels reported in aquatic toxicity studies have been converted into mg/kg wwt sediment applying the equation R.10-2:

$$\text{Effect level in mg/kg wwt} = \frac{1.08*10^{3}}{RHO_{susp}} * \text{value in mg/l} * 1000$$

The sediment toxicity results from the conversion will be in mg/kg wwt, while the predicted environmental concentrations and the sediment toxicity data in the EU risk assessment report on HBCD (EC 2008) are available in terms of mg/kg dwt. The REACH guidance presents in equation R.16-74 to convert soil wet weight data into soil dry weight data (and vice-versa, REACH 2008, R.16), which is applied to suspended matter by using Fsolidsusp instead of Fsolidsoil:

$$CONV_{sed} = \frac{RHO_{susp}}{Fsolid_{susp} * RHO_{solid}}$$

Where:

RHOsusp: Bulk density of wet weight sediment [kg.m-3] = 1150

Fsolidsusp: volume of fraction of solids in sediment [msolid3.msed-3] = 0.1

RHOsolid: density of the solid phase [kgdwt.m-3] = 2500

Therefore,

$$CONV_{sed} = \frac{1150}{0.1 * 2500} = 4.6 \text{ kg wwt/kg dwt}$$

The mg/kg wwt values have been converted into mg/kg dwt by dividing the values by 4.6.

All the above calculations have been confirmed using the EUSES software, where the equations to achieve the conversions are inbuilt in the program.

Table 4.2 below shows a data set of effects and proposed standards for HBCDD that have been ‘converted’ to sediment values. It should be noted that this is done in order to provide a *relative* comparison of the levels at which there *might* be effects in the environment with the levels that are predicted (from the environmental exposure modelling done for this study). An attempt has been made to include a range of ‘effects’ levels to form a comparative scale. In order a range of different end points from test data (such as a no observed effect concentration – ‘NOEC’) to levels that have been proposed as protective of the environment (such as the proposed environmental quality standard for HBCDD), has been used. To present a comparative scale the values were converted to the same scale – i.e. the concentration in sediment. However, it is recognised that this comparison is not definitive and represents only an attempt to ‘benchmark’ possible effects in the environment against the predicted concentrations in the part of the environment that is most at risk from concentrations of HBCDD.

Table 4.2 Data set of effects and protection limits for HBCDD that have been ‘converted’ to sediment values

Effect	Species/compartment	Concentration	Unit	Effect level	converted values (mg/kg dry wt)	Reference
Proposed AA-QSwater	Freshwater	0.00016	µg/l	Quality Standard	0.007	EC (2012)
	Marine	0.00008	µg/l	Quality Standard	0.0035	EC (2012)
Proposed MAC-QS_{water}	Freshwater	0.52	µg/l	Quality Standard	2.25	EC (2012)
	Marine	0.052	µg/l	Quality Standard	0.23	EC (2012)
Apoptosis (programmed cell death)	*Danio rerio*, zebrafish	0.05	mg/l	LOEC	217	UNEP (2010a) [citing Schriks *et al*. 2006]
Respiration Inhibtion	Activated sludge	15	mg/l	LOEC	64900	EC (2008) citing Schaefer and Siddiqui 2003
Smoltification	*Salmo salar*, salmon	11	ng/l	NOEC	0.048	UNEP (2010b) [citing Lower and Moore 2007]

Effect	Species/compartment	Concentration	Unit	Effect level	converted values (mg/kg dry wt)	Reference
Olfactory response	*Salmo salar*, salmon	11	ng/l	LOEC	0.048	UNEP (2010b) [citing Lower and Moore 2007]
Survival and reproduction	*Oncorhynchus mykiss*, rainbow trout	≥3.7	µg/l	NOEC	≥16.0	EC (2008) [citing Drottar *et al*.. 2001]
Reduced mean lengths	*Daphnia magna*, water fly	3.1	µg/l	NOEC	13.4	EC (2008) [citing Drottar and Krueger 1998]
Survival and reproduction: total number of worms	*Lumbriculus variegatus*, California blackworms	8.6	mg/kg dwt	NOEC	8.60	EC (2008) [citing Oetken et al. 2001]
Survival	*Hyallela azteca*	≥1000	mg/kg dwt	NOEC	>1000	EC (2008) [citing Thomas et al. 2003a-b]
Egg production F1 generation	*Chironomus riparius*, midge	37.8	mg/kg dwt	NOEC	37.8	EC (2008) [citing Oetken et al. 2001]

Applying the data set in Table 4.2 above to the concentrations identified in the sediment from the environmental modelling allows a semi-quantitative comparison of the levels predicted at different scales with possible effects levels. The objective is to assess the impacts that result from the additional use of HBCDD for EPS during the additional 4 years. The amount of HBCDD residing in the environment is relevant to effects, but it is not relevant to the assessment of impacts for this study. Taking relevant values for the additional concentration of HBCDD in sediment after four years' additional use in EPS, the concentrations at different scales can be compared to markers of effects.

In Table 4.3 the concentration levels are placed in ascending order to highlight where the predicted values for sediment concentrations fit with possible effects levels, and levels that are considered to be protective of the environment, i.e. the PNEC and proposed environmental quality standards.

Table 4.3 Comparison of predicted values for sediment with effects levels converted to sediment values.

Effect	Species/compartment	converted values (mg/kg dry wt)	Predicted values for the additional concentration in freshwater sediment at local/regional and continental scale (mg/kg dry wt) after four years
			0.000035 - continental
			0.0005 regional
Proposed AA-QSwater *	Marine	0.0035	
Proposed AA-QSwater *	Freshwater	0.007	
Smoltification	*Salmo salar*, salmon	0.0048	
Olfactory response	*Salmo salar*, salmon	0.0048	
PNEC Marine sediment		0.086	
Proposed MAC-QSwater *	Marine	0.23	
			0.59 - local
PNEC Freshwater sediment		0.86	
Proposed MAC-QSwater *	Freshwater	2.25	

Effect	Species/compartment	converted values (mg/kg dry wt)	Predicted values for the additional concentration in freshwater sediment at local/regional and continental scale (mg/kg dry wt) after four years
Survival and reproduction: total number of worms	*Lumbriculus variegatus*, California blackworms	8.6	
Reduced mean lengths	*Daphnia magna*, water flea	13.4	
Survival and reproduction	*Oncorhynchus mykiss*, rainbow trout	≥16.0	
Egg production F1 generation	*Chironomus riparius*, midge	37.8	
Apoptosis (programmed cell death)	*Danio rerio*, zebrafish	217	
Survival	*Hyallela azteca*	>1000	
Respiration Inhibition	Activated sludge	64 900	

* Where AA-QSwater is Environmental Quality Standard (EQS) for chronic exposure and MAC-QSwater is the EQS for acute exposure.

Conclusions on possible impacts of HBCDD from continued use in EPS

This part of the study has calculated the *additional* contribution to environmental concentration resulting from four more years' use of HBCDD in EPS. It is important to understand this because this is the consideration of the impact of only the applied-for use and only for the review period requested (four years). The study also shows the contribution that the applied-for use makes to the overall environmental concentrations taking into account HBCDD already in the environment. In Table 4.3 above it is the additional concentration that four more years of EPS manufacture and use will make that is shown, and not the overall concentration.

Table 4.3 shows that, for the sediment compartment, that at a regional and continental scale, after 4 years of additional use of EPS, the levels of HBCDD are over an order of magnitude (regional) and over two orders of magnitude (continental) lower than the most sensitive effects level (in this case the proposed marine environmental quality standard converted to a sediment values). Only at local scale would any possible effects be expected to be seen. Note that even at the local scale the value is lower than the freshwater sediment PNEC. It should be noted that the predicted levels in soil are all lower than sediment levels relative to spatial scale and thus considering sediment values represents the worst case environmental compartment.

The number of sites for EPS manufacture is limited to 14 EPS manufacturing sites in the EU, that are distributed amongst the Netherlands, Germany, France, Austria, Poland, the Czech

Republic Italy and Hungary. There may be some local scale impacts on the environment. However, the quantification of these impacts is not taken further in this report due to a lack of toxicity data to carry out a quantitative impact assessment (as also indicated by the RIVM (2012) and EC (2011) HBCDD case studies) and due to the nature of PBT substances, where a safe level cannot effectively be reached.

The environmental modelling that has been done to account for the contribution of HBCDD from the applied-for use patterns (uses 1 and 2), shows that the additional contribution of continued use of HBCDD for four additional years is limited. It seems unlikely that the additional use will have further impacts over and above what is a result of HBCDD that is already in the environment as a result of all uses. Surprisingly there does not appear to be a large volume of data in the public domain on the effects and impacts of HBCDD on the environment, specifically in sediment. Therefore a comparison of effect values derived from laboratory tests and limit values that have been derived to be protective of the environment (e.g. PNEC values and EQS values) have been converted to sediment values and compared to the concentrations in sediment and soil that result from additional of HBCDD from use 1 and Use 2. Comparing these ‘effects’ levels to the concentrations that result from additional use there would only be possible impacts at local scale.

4.4. Human health impacts

Since HBCDD is a PBT, the focus of the assessment is on the environment. Nevertheless because HBCDD is classified as toxic to reproduction (see Appendix D) the possible impact on human beings from exposure through the environment (so called ‘man via the environment’) was considered[62].

Unlike for PBT chemicals, the reproductive toxicity effects do have a threshold and thus exposure levels above this safe level indicate no effects and thus no impacts on human beings via the environment. As set out in Sections 9 and 10 of the CSR the exposure of human beings to HBCDD via food and water is below the threshold level of reproductive toxicity effect and thus impacts are not assessed.

It is also worth noting that were there to be increased imports of FR EPS from outside the EU, this would lead to an increase in emissions from transportation and associated respiratory impacts to human from increased emissions of air pollutants (e.g. CO2, NOx, SO2, and PM).

[62] It is noted that the EU RAR (EC, 2008) did indicate a need for limiting the risks to human health for repeated dose toxicity for workers during filling of HBCDD fine grade powder in production. A need for limiting the risks was also identified for toxicity on reproductive toxicity/fertility for workers during filling of HBCDD fine powder and powder in the production and adding of HBCDD fine powder and powder in industrial use. However, since the substance is listed on Annex XIV due to its PBT properties the focus of the documentation for this application is on environment and man via the environment.

4.5. Social impacts

As set out in Section 2, EPS pellet production by consortium members:

- Directly employs 559 people within the EU; and
- Indirectly employs 489 people within the EU.

EU jobs are at risk if authorisation is refused for use 1 since the most likely outcome in the short term is that EU FR EPS production will be significantly scaled back. The need for employees will in principle increase again once the pFR is available in sufficient quantities.

It is possible that there will be a significant cost in terms of redundancies, and then hiring and training costs of new employees once there are sufficient quantities of the pFR. A rough indication would be costs in the order of several hundred thousand euros. These costs and job losses could be avoided by allowing the short term continued use of HBCDD until there are sufficient quantities of the pFR for all formulators.

Since manufacturing sites may not necessarily be located in the main cities, job losses may have a more significant social impact within a local area as there are likely to be fewer opportunities for employment. It may also adversely indirectly affect induced employment in the area from reduced purchases of goods and services. Not only does this affect employment and disposable income for spending within the local economy, but a loss of jobs also means a loss of on-the-job skills and training available to EU workers.

It is difficult to estimate how long affected workers may be unemployed since there are no data on the relevant skills-base of these workers and no employment statistics for the local area have been gathered (as it would be disproportionately costly to do so). However, in the context of the current economic conditions, it is possible that employment would not necessarily be restricted to temporary/short term.

The types of jobs likely to be lost include: a mixture of skilled manufacturing jobs, R&D activities as well as office, sales, marketing and site management related jobs (e.g. with health and safety and environment legislation). Further data-gathering to understand the broad skills of these workers is likely to be disproportionate. It is likely to be sufficient to indicate the scale of possible job losses (i.e. up to 500 jobs across the EU).

The extent to which lost jobs will be displaced by new jobs within the EU from short term increased demand for alternative materials (e.g. mineral wool) will largely depend on existing stock available on the market and whether sales will come from EU production sites or from sites outside of the EU. This is explored further in the “use 2” assessment (Section 5.4).

4.6. Wider economic impacts

A net loss in EPS production, spending on goods and services and changes in employment could, in principle, have a short term macroeconomic impact in terms of a net loss per year in Gross Domestic Product (GDP) from reduced:

- Formulation of FR EPS in the EU and possibly more FR EPS imported into the EU;
- Spending on goods and services by the FR EPS supply chain; and
- Employment and increased costs in social welfare payments.

As the EU is also a net exporter of EPS pellets, a refused authorisation would lead to a reduction in exports making the EU trade balance worse, i.e. fewer exports and more imports. This will lead to opportunities for non-EU producers to gain a greater market share in this global market.

Although the scale of lost sales of EPS pellets is significant at around €1.2bn (NPV) over the period 2016-2019, at this level a refused authorisation is unlikely to lead to any significant macroeconomic impacts (e.g. impacts would need to be in the order of tens/hundreds of billions to have a macroeconomic impact).

4.7. Comparison of costs and benefits

Table 4.4 summarises the main costs and benefits associated with a refused authorisation for "Use 1 – formulation of EPS". Note that some impacts are not monetised, so monetary impacts are presented alongside qualitative and quantitative impacts[63].

[63] The qualitative assessment of the some impacts largely reflects the common principle in socio-economic analyses of ensuring a proportional analysis is undertaken for the scope and scale of impacts being appraised.

Table 4.4 Main costs and benefits of a refused authorisation for "use 1" (2015-2019)

Type of impact	Costs of a refused authorisation for "Use 1"	Benefits of a refused authorisation for "Use 1"	Net impact
Economic	Lost sales to EU FR EPS pellet producers: €1,17m (PV 2015-2019)	-	Net economic cost to EU of €1,175m (PV 2015-2019)
Human health	Increased transportation emissions (e.g. CO_2, NOx, SO_2, and PM) from FR EPS being imported into the EU may lead to respiratory impacts to humans from increased emissions of air pollutants	No impacts on human beings via the environment as exposure is below threshold so no reproductive toxicity effects expected	No significant change in human risks
Environmental	Increased transportation emissions (e.g. CO_2, NOx, SO_2, and PM) from FR EPS being imported into the EU	Additional HBCDD released to the environment considered to be very low from continued use for 4 years. Total releases to the environment over 4 year of up to 1.98 tonnes of which 84% of the HBCDD released is either degraded in the environment within the four year period or removed in sewage treatment (and then incinerated or landfilled). Up to 190kg may be found in freshwater and marine sediment and up to 130kg found in soil.	Very small improvement in HBCDD released to the environment of up to 1.98 tonnes over 2015-2019 for use 1 and 2
Social	Up to 500 jobs could be at risk in the short term	-	No significant change in social impact
Macroeconomic	Reduced EU sales revenue (contribution to GDP) and worse EU trade balance from increased imports and reduced exports	-	No significant change in macroeconomic impacts

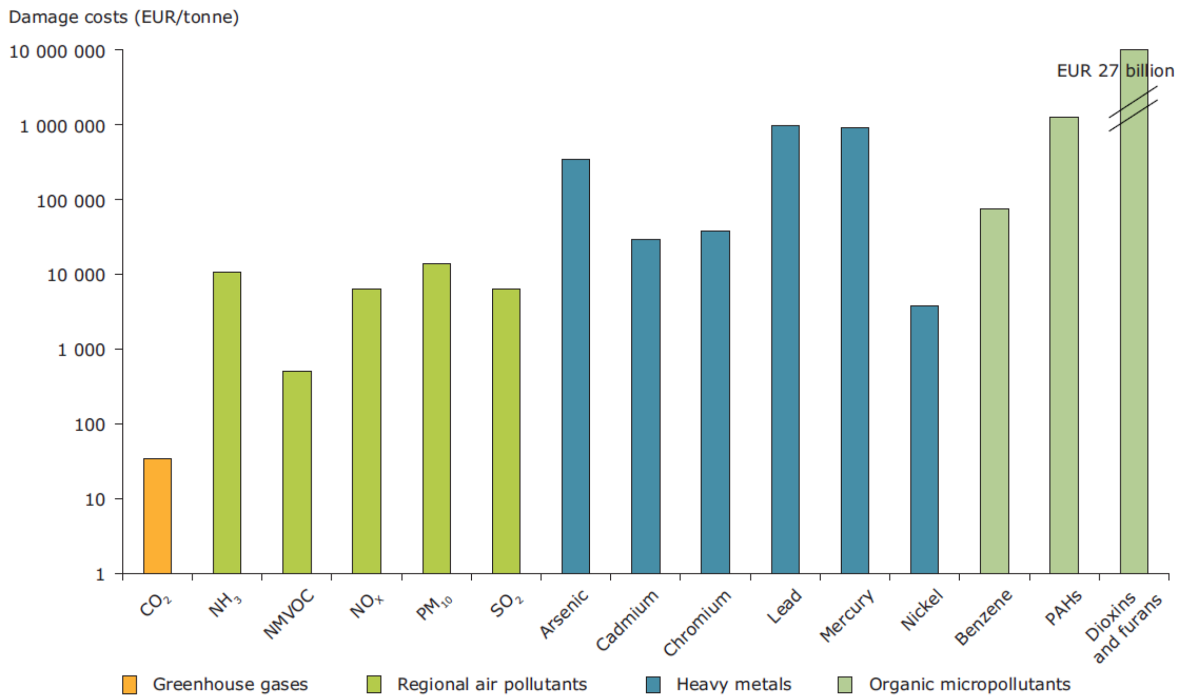
Notes: Present value (PV) calculated using a 4% discount rate in accordance with REACH SEA guidance (2011).

Based on the cost-benefit analysis summarised in Table 4.4, it is evident that society overall would be worse off if authorisation for the continued use of HBCDD to make FR EPS was refused. This is due to the estimated significant net economic impact from lost production value (€1.2billion in present value terms), which outweighs the estimated net environmental benefit of reducing HBCDD of up to 190kg in freshwater and marine sediment and up to 130kg in soil (from uses 1 and 2).

As it is not possible to put a monetary value of up 1.98 tonnes of HBCDD in the environment, it is worth examining it from a cost per tonne perspective. The cost of a refused authorisation is estimated at €593,547/kg[64] of HBCDD avoided into the environment (or €594million/tonne) and even higher for actual releases that end up in freshwater, marine sediment or soil at €3,672,572/kg[65] avoided (i.e. excluding those removed from treatment or degraded) (or €3.7billion/tonne).

In order to put these costs per tonne into perspective, Figure 4.14 shows estimates of EU average damage costs per tonne emitted for a number of different air pollutants (which is an area where it has been possible to value impacts). It shows that costs per tonne range from several euros per tonne (CO_2) to around a million per tonne for lead, mercury and PAHs.

Figure 4.14 Estimates of the European average damage cost per tonne emitted for selected air pollutants



Source: EEA (2011)[66]

Therefore estimates of either; €594m/tonne and €3.7bn/tonne (for HBCDD) are significantly higher making it clear that even if the benefits to the environment were estimated that the benefits of a refused authorisation would not outweigh the costs. The €/t figures are also

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64 Calculation = 1,175,223,077 / 1,980

65 Calculation = 1,175,223,077 / (130+190)

66 EEA (2011) – "Revealing the costs of air pollution from industrial facilities in Europe" – A technical note by the European Environment Agency. Available at: http://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&cad=rja&ved=0CDgQFjAB&url=http%3A%2F%2Fwww.eea.europa.eu%2Fpublications%2Fcost-of-air-pollution%2Fdownload&ei=_rGoUt7WIoOu7AbjzICYBA&usg=AFQjCNEmrKcuFeTa4axaISoWbzrTl0Gnhg&bvm=bv.57799294,d.ZGU

based on worst case estimates (in terms of releases to the environment) as it assumes the applicants only use HBCDD for an additional four years but as noted earlier, consortium members are committed to switching to the pFR as soon as possible and in practice will use some pFR and HBCDD over this period with the intention to completely phase out use of HBCDD by 2019 (sooner if possible). The cost per tonne figures would therefore be around three times higher if it were based on just the expected volume of HBCDD used over 2015-2019.

Other non-monetised impacts do not change this conclusion because no changes in risk to human health were identified, whilst the social and macro-economic impacts are judged to reinforce the net economic loss.

5. COST BENEFIT ANALYSIS (CBA): USE 2

5.1. Introduction

This section sets out an assessment of the impacts of a refused authorisation (i.e. the non-use scenario) relative to the baseline scenario. The assessment is based on the most likely responses identified in Table 3.4, which covers a refused authorisation for Use 2 (manufacture of FR EPS). All relevant impacts are considered ranging from economic and social impacts as well as environmental and human health risks. This is consistent with recommendations set out in the ECHA SEA guidance.

As authorisation is being sought for continued use with a review period of 4 years, the analysis focuses on the impacts for this period only (i.e. 2016-2019). However, since HBCDD is classified a PBT substance, the environmental impacts are considered over a longer time to account for its persistent presence in the environment. The geographical boundary of the analysis is the EU-27.

5.2. Economic impacts

5.2.1 Lost sales to FR EPS converters

In Section 4 it is estimated that a refused authorisation for formulation of FR EPS (use 1) with HBCDD *could* result in a shortage of FR EPS, as it is predicted that there will be insufficient global supply of the pFR over the whole review period for both XPS and EPS producers. However, if it is possible for non-EU FR-EPS producers to supply a greater volume of their pellets to the EU (containing the pFR which meets all end user requirements) and using HBCDD for non-EU customers (where possible to do so) then EU FR EPS converters may have sufficient supply of EPS pellets (from imports into the EU). Therefore, as a lower bound estimate, it could be assumed that there will be no loss in sales to FR EPS converters.

If there is, however, a shortage of FR EPS pellets (which is more likely) it will mean that converters (manufacturers of articles of FR EPS – use 2) will not be able to make as much FR EPS articles (i.e. boards and blown beads).

Access to data on the converter market is limited (compared to formulation of pellets) with the confidential CMAI study (2009)[22] for CEFIC – EBFRIP being the most up-to-date and reliable source available for the EU-27. As detailed in Table 2.18, there are around 587 converters across the EU27. Given the dispersed nature of the sector, it is not possible to gather the required data through surveys, including even through trade associations for each member state (i.e. contacting 27 Member State associations). However, for completeness, a questionnaire (see Appendix E) was sent out to converters through consortium members. This does provide some additional supporting evidence, but only reflects data/opinions from a subset of converters and cannot be interpreted as representative.

According to the CMAI report (2009), in 2007, the value added by converters (i.e. the value of their production process alone, which excludes any value from making EPS pellets) was

€119m based on total EU FR EPS in construction of 882kt. This translates to an added value of around €135 per tonne of FR EPS manufactured (i.e. made into FR EPS articles - boards and blown beads). Note that the value added estimate does not double count with impacts already estimated in use 1[67].

Table 5.1 shows the estimated sales loss to converters (loss in value added) as a result of reduced supply of FR EPS pellets. It shows that €113 million value added (in present value terms) could be lost from reduced production from 2015 to 2019 as a result of reduced supply of FR EPS pellets on the market (made with pFR rather than HBCDD).

Table 5.1 Loss in production to converters (€ millions) from reduced FR EPS pellet supply

	2015	2016	2017	2018	2019	Total	Total (PV)
Lost sales value to EU convertors (€m)	26	25	10	0	62	124	113

Notes:

1. Figures are rounded to nearest unit and rounded to larger unit of measure (i.e. €m) to avoid spurious accuracy.
2. It is assumed that authorisation for use 1 is refused and therefore no imports of FR EPS pellets into the EU will be allowed which contain HBCDD. Imports of FR EPS containing pFR will however be allowed.
3. Value added by conversion of EPS ((€135/t) is based on the CMAI (2009) study and is assumed to be constant over time. This value is taken at the EU level and applied to the shortfall in volume of FR EPS beads no longer produced by the consortium during the period 2016-2019.
4. Present value (PV) has been estimated using a discount rate of 4% as recommended in the ECHA SEA guidance (2011) document with a base year of 2015.

5.2.2 Increased sales to manufacturers of other insulation materials

If it is possible for non-EU FR-EPS producers to supply a greater volume of their pellets to the EU (containing the pFR which meet end user requirements) and using HBCDD for non-EU customers (where possible to do so), then EU FR EPS converters may have sufficient supply of EPS pellets (from imports into the EU). Therefore EU consumers may not need to switch away from FR EPS. <u>All EU sales revenue loses in Table 4.1 (FR EPS formulators) and Table 5.1 (FR EPS convertors) are then expected to occur.</u>

If there is a shortage of FR EPS in the EU, the most likely response by end users will be to switch to another form of insulation material (rather than have no insulation or use non-FR

[67] By avoiding double counting, the economic impact results of use 1 can be added to any results presented in this use 2 economic impacts section.

material). All EU sales revenue loses noted in Table 4.1 (FR EPS formulators) and Table 5.1 (FR EPS convertors) are then expected to be redistributed within the wider thermal insulation market.

From a technical perspective, only certain FR insulation materials will be a suitable alternative to FR EPS depending on the given end application (e.g. ETICs, wall insulation, flat roof, pitched roof, etc.) due to factors such as water/moisture resistance and rigidity.

Based on data provided by the consortium, for the main FR EPS building applications, extruded polystyrene (XPS), polyurethane foam (PU) or mineral wool (MW) are the most likely substitutes for the reduction in FR EPS. This is represented in Table 5.2 where the dominant material for a specific application is highlighted in grey and the key EPS uses highlighted in red (based on the EU MEPS data in Table 2.12). The ticks (✓) indicate where the material can be used (i.e. meets technical requirements).

Table 5.2 Main applications of EPS within construction – EUMEPS estimate

Key building applications		EPS	XPS	PU	MW
Wall	Perimeter	✓	✓		
	ETICS	✓			✓
	Cavity	✓		✓	✓
	Internal	✓		✓	✓
	ICF	✓	✓	✓	
Roof	Flat	✓	✓	✓	
	Pitched			✓	✓
Floor		✓		✓	

Based on the top ten FR EPS building uses (EUMEPS sales data shown in Table 2.19) a series of assumptions can be made to determine the substitute material end users would switch to instead of FR EPS. It is assumed that if another material is the dominant material (e.g. XPS is the dominant material for perimeter and MW is for cavity walls) that it would fully replace (100%) FR EPS use. If FR EPS is the dominant material (e.g. for ETICS and ICF) then the replacement of FR EPS sales would be evenly distributed between any suitable materials. The assumed redistribution of FR EPS sales by building application is set out in Table 5.3 below based on expert judgement of the consortium members.

Table 5.3 Redistribution of FR EPS uses by building application

Top 10 FR EPS building uses	Total FR EPS sales (%)	Redistribution of EPS use assigned to:
Further information has been provided confidentiality identifying the main uses of FR EPS and use specific values		

Table 5.4 aggregates the estimates by insulation material (under scenario 1). It shows that the shortage in EPS production would be offset by increased use of MW (46%), PU (29%) or XPS (26%). However, since XPS also uses the pFR, the likelihood of increasing XPS production over this period is rather limited. Therefore, an adjustment is made under scenario 2, reflecting a much smaller increase in XPS (5% - limited to perimeter boards) and a higher displacement with PU (35%) and MW (60%) in particular given its dominant overall status in the market. Scenario 2 is considered to be more realistic and is therefore taken forward for further assessment.

Table 5.4 Summary of redistribution of FR EPS use

Insulation product displacing FR EPS	Scenario 1: Volume of FR EPS displaced (%)	Scenario 2: Volume of FR EPS displaced (%)
MW	46%	60%
PU	29%	35%
XPS	26%	5%

Notes:

1. Scenario 2 is considered to be more realistic and is taken forward for further assessment.
2. Figures are rounded to nearest 5% to avoid spurious accuracy
3. A lower share is given to PU as there some reservations around PU/PIR which has a much smaller share of the EU market (~10%[68]) to adequately supply more material. Similar to EPS, PU/PIR is a lightweight material will only be competitive to transport within the national boundaries and therefore there is not expected to be a supplemented supply from outside the EU.

From the overall societal analysis, the main economic impact, in terms of production value and sales, is largely one of redistribution from EPS to other FR insulation materials. From an

[68] PLASTEUROPE.COM – Thermal Insulation – "*European market to reach over EUR 10bn by 2017/ Polymers lose out to fibres as demand rises for fire properties / Turkey leads growth in eastern Europe*" (Published on 19.03.2013). Available at: http://www.plasteurope.com/news/THERMAL_INSULATION_t224871

industry perspective, there will be some winners (MW and PU manufacturers) and some losers (EU EPS manufacturers). It is estimated that most redistribution of sales will go to EU firms based on the number of manufacturers already in the EU for these other materials (which is shown in Table 5.5 below).

Table 5.5 Number of EU manufacturers of mineral wool, PU and XPS

Insulation material	Number of manufacturers in EU
Mineral wool (MW)	19
Polyurethane (PU)	33
XPS	56*

Notes:

1. * The CMAI study indicates there are actually 56 XPS production facilitates in the enlarged EU (2007)
2. Data is based on a search for information by manufacturing associations including: ANPE, APIPNA, BRUFMA, EPIC, EURIMA, EXIBA, FILMM, FMI, IPUR, MIMA, NVPU, Plast Industrien, PU Europe, ROSIZOL, SIPUR and SNAP.
3. Data was screened to only reflect the number of manufacturers of insulation materials. Manufacturers of raw materials in the production of insulation materials are not included in the estimates above.
4. In the rare case that manufacturers produce more than one insulation material, they are counted twice. As such, the total number of plants displayed in the table above does not add to the actual number of manufacturers in the EU.

5.2.3 Functioning of the market (price competition)

A refused authorisation for the manufacture of EPS using EPS pellets containing HBCDD (use 2) is predicted to have a negative impact on the degree of competition in the market. By restricting the market to production of FR EPS only with the pFR, there is expected to be a shortage in EPS produced within the EU given the limited supply of the pFR. As noted in Section 4.2.1, it may however be possible that non-EU FR EPS converters prioritise their pFR EPS pellets to the EU market, putting EU manufacturers at a significant competitive disadvantage.

As shown in Table 5.2 in particular, FR EPS is the dominant material for specific building applications (due to its performance and price) and provides competition against other materials (i.e. XPS, MW and PU) for other building applications. There is a risk that the EU market will be less competitive for a short period of time. EU FR EPS manufacturers faced with a shortage of supply of the pFR will either have to increase their prices or accept a significant loss in production value (as estimated in Tables 4.1 and 5.1). Faced with reduced competition and growing demand for insulation materials, other material manufacturers (MW and PU in particular) may be able to exploit market power, based on the knowledge that end users cannot easily get access to the EPS and XPS. It is unlikely that other insulation material prices will be significantly constrained by threats of imports given the nature of the product (e.g. size, weight and price).

Equally, these (non-EPS) producers may not increase price (given the large number of producers already competing against each other for each materials) in order to gain a more dominant position on the market (i.e. by reducing EPS market share of the total insulation market further).

There could also be a negative impact on price competition if there is a significant reduction in the number of convertors on the market. As manufacture of EPS (i.e. converters) typically occurs close to their end markets, there are a large number of convertors (587 as shown in Table 2.18) within the EU who are typically SMEs who may not be able to continue to operate if there is insufficient supply of EPS pellets. This could affect the long term competitiveness of EPS to regain its market share in the thermal insulation market as well as adversely affecting SMEs (convertors) across the EU. The net result could be higher costs to consumers.

Given the level of uncertainty concerning pFR supply and its effects on possible changes in price, this has not been monetised to avoid conveying a false degree of accuracy which could undermine the reliability of results where quantification of impacts has been possible.

5.2.4 Net cost to final consumers

If it is possible for non-EU FR-EPS producers to supply a greater volume of their pellets to the EU (containing the pFR which meets all end user requirements) and using HBCDD for non-EU customers (where possible to do so) then EU consumers may not necessarily face a higher net cost to using EPS (compared to a situation where FR EPS is available from an EU supplier using the pFR).

However, if there is a shortage of FR EPS in the EU and end users switch to another form of insulation material, there will be a net cost to EU consumers. The overall scale of any changes to consumers will largely depend on changes in the price of EPS relative to that MW and PU.

In terms of the price of various insulation materials, the availability of reliable price data is limited, which restricts the scope of a comparative price analysis. Further, there are a number of material-specific marketing documents suggesting that their respective material is the most cost effective[69] insulation material depending on the type of building application, thickness and brand used. Wherever possible, these were avoided with a preference for impartial sources

[69] Cost effective here refers to the price of the material for a given thermal insulation characteristic (e.g. U value or R value).

Table 5.6 below is taken from the European Commission's (EC 2010) *Green Public Procurement Thermal Insulation Technical Background Report*[45] which provides a third party data source for price data per unit area of EPS and rock/stone mineral wool. It shows that depending on the board thickness used for a given thermal performance EPS is generally cheaper than MW.

Table 5.6 Relative prices of EPS and mineral wool

Type of insulation	Thermal performance (U-value)	Price/m^2
Rock mineral wool	0.034-0.036	€4.40 - €7.80
EPS	0.033	50mm Board €3.14 100mm Board €6.28 65mm Cavity Fill €4.40 (including labour for installation)

Source: EC (2010)[45]

In order to validate these estimates and to also include other insulation products, additional sources of data were sought. Prices for various types of FR insulation materials used for building applications were sourced from available information. The insulation price analysis relies on a database of 106 products[70] for the following materials: EPS, XPS, PIR[71] and MW.

Price data were collected for commercial products that could be used for multiple purposes including wall, loft, floor, roof, pipe and acoustic insulation. The number of data points was reduced (initially from 212 to 106) by excluding specialist building products (with much higher prices) that were assumed not to be appropriate to include when comparing general price differences between types of materials.

Single pack prices were used, avoiding any bulk order discounts (which apply for larger orders). Confirmation was sought from the supplier that pack prices were comparable between the different types of insulation materials[72] to allow price comparisons of different

70 These observations were collected from http://www.just-insulation.com/. This source was chosen in light of difficulty in finding alternative sources which presented insulation price data in a consistent and comparable manner.

71 Polyurethane foam (PUR) is not featured in this analysis due to a lack of suitable data. However, it is argued that conclusions about the pricing of PIR can be applied to PUR as most sources in the literature tend to consider these two materials jointly.

72 Based on personal communication with the supplier.

materials to be made consistently and on a per unit basis. Additional data on the thicknesses and insulation properties (R-value[73]) were also collected to adjust for thermal performance. As each product has a different R-value depending on its thickness and thermal conductivity (lambda (λ)- Value), the price of each material is divided by its corresponding R-value to produce a price per R-value. This adjusted price, measured in € per R-value or € per 1 m^2K/W therefore represents the price paid for a given insulation material with an R-value equal to 1.

Two thicknesses were considered, 30 mm and 40 mm, based on data availability for all four insulation materials. Tables 5.7 and 5.8 present the highest, lowest and average prices per R-value of EPS, XPS, PIR and mineral wool in € per 1 m^2K/W[74].

Table 5.7 Price per R-value (€ per 1 m^2K/W) of insulations boards of thickness equal to 30 mm

Material	Low price (€ per 1 m^2K/W)	Average price (€ per 1 m^2K/W)	High price (€ per 1 m^2K/W)
EPS	-	22.24	-
XPS	-	22.24	-
PIR	-	11.90	-
MW	23.78	30.93	37.34

Table 5.8 Price per R-value (€ per 1 m^2K/W) of insulations boards of thickness equal to 40 mm

Material	Low price (€ per 1 m^2K/W)	Average price (€ per 1 m^2K/W)	High price (€ per 1 m^2K/W)
EPS	19.04	21.15	23.27
XPS	19.04	21.15	23.27
PIR	-	10.61	-
MW	17.84	21.91	25.91

For both insulation board thicknesses (30 mm and 40 mm[75]) and for an R-value equal to 1 m^2K/W, MW has a slightly higher price compared to EPS and XPS, which have identical prices. Overall, PIR presents the lowest price per unit per R-value.

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73 The R-value is defined as the thermal resistance of a material and is calculated in the following way: R- value (m^2K/W)= Thickness of insulation material (m) / Thermal conductivity (W/mK) where the thermal conductivity is the λ-Value in W/mK which measures the insulating capacity of a product designed for thermal performance. The higher the R-value of an insulation material, the more the material is considered to be able to resist the transmission of heat. A relatively higher R-value is therefore the mark of a better insulation material.

74 Prices are converted from £ to € using the European Commission's exchange rate on 03/09/2013 of 1.18 €/£. Source (accessed on 03/09/2013): http://www.ecb.europa.eu/stats/exchange/eurofxref/html/index.en.html

A basic interpretation could therefore be that most consumers could be financially worse off by having to switch to MW compared to using EPS whereas some maybe financially better off by switching to PU/PIR. It is however difficult to conclude this as there will also be additional trade-offs between using EPS compared to either MW or PUR/PIR. For example MW would have to be "pinned", i.e. secured/attached, if being used for wall insulation at an added cost of time and material needed for pinning. To achieve the same thermal performance more MW is needed to increase the depth of insulating material, therefore more material is handled. PUR/PIR boards are generally more expensive (board size) than EPS boards, but where suitable, have a better performance (e.g. thermal conductivity, weight and handling). Depending on the overall thermal performance of the building that is required, PUR/PIR may or may not work out to be more cost effective to EPS.

As part of the ECHA (2013)[76] study, the abatement costs of no longer using HBCDD in EPS and XPS in building applications were considered. This was focussed on the costs in relation to using PUR/PIR and MW as alternative insulating materials to EPS. The ECHA 2013 study made use of the price data in the Klif study (2011)[47] which is represented below in Table 5.9.

Table 5.9 Examples of Prices for Selected Products (Klif, 2011)

Material	Price for 100mm (€/m^2)	Price for Functional Unit (€/m^2)[Note 1]
Flat roof insulation		
EPS	€13-18	€13-18
XPS	€23-27	€22-24
Mineral wool	€22-40	€23-48
PUR/PIR	€24	€16
Floor Insulation		
EPS	€13-18	€13-18
XPS	€20	€20
PUR/PIR	€23-25	€17-18
External wall insulation		
EPS	€15	€15
Mineral wool	€16-20	€16-21

Notes:

[75] A comparison between the prices presented in 5.7 and 5.8 shows that, in general, a decrease in price occurs when the thickness of a material increases. This is due to the fact that an increase in thickness will increase the R-value. In turn, an increase in the R-value will decrease the price per R-value of the material in question.

[76] ECHA (2013) – "*Estimating the abatement costs of hazardous chemicals - A review of the results of six case studies*" – A report prepared by AMEC for ECHA: http://echa.europa.eu/documents/10162/13580/abatement+costs_report_2013_en.pdf

1. Functional unit: insulation needed for thermal resistance of 2.857 m2·K/W corresponding to 10 cm insulation at a thermal conductivity 0.035 W/(m*K)
2. It is important to note that prices for the insulation materials vary significantly depending on application (roof, wall and roof insulation) and quality of individual products will vary amongst applications and brands. Parameters such as the thermal conductivity or compressive strength of the materials required for each use have a great impact on the price. For example, the price of an EPS board increases by about 8% going from a board with a thermal conductivity of 0.040 W/(m·K) to a board of a thermal conductivity of 0.035 W/(m·K).

The results from the ECHA (2013) study confirmed what has been found from publically available sources for this present study. In particular that:

- Switching from FR EPS to MW is likely to result in a higher cost to the end users; and
- Switching from FR EPS to PUR/PIR results in a higher purchase cost (e.g. cost per board), but on a functional unit basis (i.e. factoring in thermal performance) it is more marginal (e.g. for flat roof insulation the cost of PUR/PIR is €16/m^2 and FR EPS €13-18/m^2, which could be higher or lower depending on the range).

The ECHA (2013) study also estimated what the added (abatement) costs to consumers are relative to estimated emissions saved (note these are different to those estimated specifically from consortium members – which is shown in Tables 4.1 and 5.1). It is stated that the cost estimate is based on ECHA guidance on compliance costs but limited (supporting) calculations are provided to determine/verify how they were calculated. Table 5.10 therefore represents the results from the ECHA study which shows the estimated incremental cost (additional annual cost) of switching from total EU FR EPS consumption to either PUR/PIR or MW is €673 million per year.

Table 5.10 Summary of cost curve data from the ECHA (2013) study

Material	Incremental cost (€k)	Incremental emission reduction (t)	Incremental cost-effectiveness (€k/t)
Replacement of HBCD in EPS used for roof insulation with PUR/PIR	21,120	844	25
Replacement of HBCD in EPS used for floor insulation with PUR/PIR	247,808	2,475	100
Replacement of HBCD in EPS used for external wall insulation with mineral wool	404,096	2,306	175
Total	**673,024**	**5,625**	-

Notes:

1. All data on costs and emission reductions are at an EU level
2. See Appendix A of the ECHA study for details on how these figures have been calculated. It indicates the replacement of EPS based roofing insulation with PUR/PIR costs €25,000/t; ETICS with mineral wool for €175,200/t and €100,120/t for PUR/PIR foams. In total these add up to €300,000/t of HBCDD lost.

The ECHA (2013) study €673m per year estimate is based on the fact that the added cost as a result of no longer using 5,625/tonnes of HBCDD per year. Applying this to consortium-specific HBCDD that can no longer be used (See Table 2.12 which factors in use of any available pFR) Table 5.11 sets consumers may have to pay €750m (PV) in total from switching to other insulation materials over the period 2015-2019.

Table 5.11 Net cost to consumers (2015-2019)

Further supporting information has been provided confidentiality in order to estimate loss in sales specific to the consortium

Notes:

1. Figures are rounded to nearest unit and rounded to larger unit of measure (i.e. €m) to avoid spurious accuracy.
2. This excludes the possibility of consumers using any existing stock of FR EPS available after the sunset date. This possibility might only be applicable to part of the 2015 figures.

5.3. Environmental and human health impacts

5.3.1 Avoided releases of HBCDD to the environment

The substance (HBCDD) will be captured in the polymer matrix (EPS) and it is believed that in reality that there is low likelihood of releases to the environment through manufacture and use of EPS articles. However, there is not sufficient information to disregard emissions to the environment and as a worst case conversion of EPS containing flame retardants as discussed in the OECD Emissions Scenario Document for Plastics Additives (OECD 2009) is followed for the assessment of exposure in the CSR.

EPS conversion takes place in a closed process. However, some of the losses are of particulates, some of the loss is likely to be initially to the atmosphere (as dust), but ultimately all particulates will be removed or settle and losses will be to solid waste or to waste water as a result of equipment wash-down. Therefore, as a worst case it is assumed that all this loss will eventually be released to waste water. Volatile losses are initially losses to the atmosphere. However, the processes involve elevated temperatures and subsequent condensation could result in losses to liquid waste. As a worst case it is assumed that half of this is lost to waste water and half is lost to the atmosphere. The consequence of this is that HBCDD end up in the environment as a result of conversion.

As shown in the mass balance in Table 2.22 release to the environment from the conversion use is the highest total amount, although this still represents a very small fraction of the total use volume. Since conversion is dispersed (i.e. there are many hundreds of converters in the EU) the concentration in the environment will be at regional and continental scale, i.e. the HBCDD in the environment is not modelled to be localised at particular sites.

Included in the assessment of this use is the service-life of the EPS articles, again migration of the substance from the articles is expected in reality to be low, but studies have predicted some losses and these were used in the CSR to calculate losses from boards over their service life. As with conversion use is much dispersed (i.e. use of EPS article (insulation boards happens all over the EU), the concentration in the environment will be at regional and continental scale, i.e. the HBCDD in the environment is not modelled to be localised at particular sites.

The distribution of HBCDD in the environment as a result of continued use of HBCDD in EPS is described in detail in Section 4.3 and in the detailed report at Appendix F. In addition the possible impacts that may result from continued use of EPS are described at Section 4.3. It can be seen from Section 4.3 that the possible impacts in the environment in terms of toxic effects could be considered to be negligible at regional and continental scale. However, the possible impact of HBCDD as burden, in terms of total amounts in the environment, cannot be disregarded.

The releases from conversion and use as a result of HBCDD no longer being available, for the total of four additional years use would be 800 kg from conversion and 230 kg from service life. It should be noted that this was calculated using a worst case of 31,829 tonnes use over the four years.

The impacts of users of EPS switching to other insulation products are discussed below.

5.3.2 Change in environmental and human health risks from short term switch in insulation materials used

5.3.2.1 Introduction

In Feb 2013, Plastics Europe finished a study titled "*multi-criteria evaluation and comparison of insulation materials in the Europe*". The result is an assessment of the contribution to sustainability, as well as a guide to the advantages and disadvantages of these materials used in buildings.

The comparative analysis focuses on the most important insulation materials in their building applications using Germany and Italy as reference countries (Sweden was also chosen but a lack of data meant this was not possible) and covers:

- More than 300 insulation products;
- Applications: flat roof, pitched roof, wall (both ETICS and ventilated façade), perimeter insulation (both below and above foundation slab);
- Materials;

- Fibres: Glass wool, stone wool, wood fiber, cellulose slabs, hemp/flax; and
- Foams: EPS/Grey EPS, XPS, PUR/PIR, foam glass, aerogel.

The report is not available to the consortium (confidential) but some headlines results were made available[77] and directly quoted[78] below:

- All insulation materials, including the impact of necessary constructions and adaptations of the building, have an overall positive effect on the sustainability of a building calculated over its lifecycle;
- There is no single material that is best in all applications. Results depends significantly on the application and construction;
- The performance of natural based materials is not necessarily better than plastics or minerals; and
- The climate region has only a minor effect on the results.

On a material level the headline summaries were (again directly quoted[78]):

- Mineral wool:
  - Glass wool has in general more advantages than stone wool. Glass wool is best in most of the production aspects with the application of ventilated façades and pitched roof (between rafters)
  - Currently produced mineral fibres have no hazardous potential except for dust, but adequate workers' protection can deal with the related exposure risk. However there is hardly any recovery potential with mineral fibres
  - Two common applications of foam glass are compact flat roof and slabs fixed to the perimeter wall. There is no potential risk of exposure to hazardous substances. Its summer smog potential is the lowest in both applications. All other indicators were worse compared to the alternatives.

- EPS - is strong with three production LCIA indicators in the applications flat roof, ETICS and perimeter:
  - Investment costs lowest within these applications. The grey type is always more favourable than white EPS. The production LCIA indicator for the photochemical ozone creation potential (POCP) is normally worse in comparison to other materials; the reason is the use of pentane as a blowing agent that contributes to ground-level ozone creation when released from the foams.

[77] It is not clear to what extent this report can be provided directly to ECHA if requested. It is understood that results were made comparable by using same U values.

[78] The authors of the SEA (PFA and eftec) have not had access to this report so cannot verify or reject these key findings.

- XPS - has been proposed for perimeter, flat and pitched roof (over rafters) applications
    - Environmental performance is similar to EPS but with differences derived from different surface weights and a lower summer smog potential (POCP)

- PUR/PIR - is always best in terms of thickness per functional unit.
    - In the flat roof and ETICS application the aspects of sustainability are comparable to EPS standard
    - A much lower recovery potential is accompanied by lower summer smog potential
    - Its potential risk is the lowest among plastic foams and comparable to mineral materials.

- Natural fibre products - have been analysed for the ventilated façade (hemp fibre in Germany, flax fibre in Italy) and ETICS (wood fibre in Germany) applications
    - The advantages of natural fibres are enhanced recovery potential and low potential risk
    - The main disadvantage is a usually higher lambda value with relatively high densities
    - Hemp and flax fibre slabs in the ventilated façade have advantages in climate friendliness, application suitability and the low potential risk
    - Wood fibre slabs in the ETICS application have high densities. Their LCIA indicators for production are worse than plastic foam solutions.

In order to provide a verifiable comparison of EPS vs. PUR/PIR, XPS and MW a simple assessment has been carried out at the various “life cycle” stages:

- Raw materials consumed;
- Production process;
- Use / performance; and
- End of life.

It is noted here that it was deemed to be disproportionate to do a full life cycle assessment comparing EPS to other materials, as this would be a significant study in itself.

5.3.3 Comparison of raw materials consumed

Mineral wool is made with inorganic mineral fibres whilst PUR, PIR, EPS and XPS are derived from organic chemicals. Table 5.12 describes the material used to make the four broad insulation products (EPS, XPS, MW and PUR/PIR) and presents a high level review of any potential environmental and health risks associated with these materials.

Table 5.12 Raw materials used by type of insulation product

Type of insulation product	Materials used	Environmental and health risk associated with materials used
Mineral wool (stone/rock, glass and slag wool)	- Molten glass, stone or slag (industrial waste) -Stone wool: 98% inorganic rock or slag, a thermosetting resin binder (an adhesive), impregnation oil -Glass wool: 95-96% inorganic material[79] -Slag wool: mostly blast furnace slag (waste)[80]	The risk to the environment would be reduced as mineral wool is relatively chemically inert. There were concerns for the human health risks from inhalation exposure to mineral wool fibers but IARC has classified rockwool and slagwool as Group 3, not classifiable as to their carcinogenicity to humans. Rock wool can be recycled. Netherlands health experts[81] reported (see Appendix 3 of the AoA) that stone and glass wool consist of fibers which, on inhalation give rise to accumulation in the body, an irreversible process. Once the material has entered the lung, it can never get out and acts as a disturbing element. Chronic lung problems, including asthma and pulmonary fibrosis may be the result. The fibres of mineral wool (stone wool and glass wool) have traditionally been bonded with a resin binder, based on phenols and formaldehyde. The concentration of the binder is indicated to be in the range of 1-17% depending on the specific application. Most of the formaldehyde is removed by the manufacturing process. Stone wool may potentially release formaldehyde from the construction into indoor air. Formaldehyde emission rates from uncovered stone wool falling from 72 to 50 µg/m^{2}h over a period of 28 days (reported in KLIF 2011). Formaldehyde is classified carcinogenic in the European Union (Carc. Cat. 3; R40).
PUR/PIR	-Liquid polyol, liquid polymeric isocyanate, Methylene Diphenyl di-Isocyanate (MDI)[82], HFCs/CO_2/pentane[2] -PIR contains more MDI than PUR	-Isocyanurate: pott respiratory sensitiser, highly persistent material -MDI: allergen and sensitizer. Possibly carcinogenic (to humans) - HFCs: hazardous blowing agents which require care when handling during installation and potential depletion of ozone layer

[79] http://www.eurima.org/regulatory/eu-support-schemes

[80] http://ec.europa.eu/environment/gpp/pdf/thermal_insulation_GPP_%20background_report.pdf

[81] A letter from Dutch health experts to Mr. Minister, Dr. L. F. Asscher , Ministry of Social Affairs and Employment (See Appendix 3 of the AoA)

[82] http://www.brufma.co.uk

Type of insulation product	Materials used	Environmental and health risk associated with materials used
EPS	-Solid polystyrene beads, pentane gas, peroxide and HBCDD (0.7% of the final product) as a flame retardant	- Organic peroxide initiator: can be eye and skin irritants, chronic toxicity to the aquatic environment. - Pentane is a volatile organic chemical (VOC) – meaning it has the potential for damaging the ozone layer (controlled by Solvent Emissions Directive and largely release from product before service life). - HBCDD is listed as a PBT under REACH, also classified as toxic to reproduction (Rep Cat 2)
XPS	- Mixture of solid polystyrene crystals, Hydrofluorocarbon (HFC) or pentane, and HBCDD - XPS requires relatively more HBCDD (0.5-3%) to achieve the same fire performance standards as EPS	- HFCs: hazardous blowing agents which require care when handling during installation and potential depletion of ozone layer - Pentane is a VOC - HBCDD is listed as a PBT under REACH, also classified as toxic to reproduction (Rep Cat 2)

From a material basis, XPS uses the same kinds of materials as EPS so there is no major change going from EPS to XPS. A switch to PUR/PIR will have a change risks in terms of risks associated with using isocyanurate (potent respiratory sensitiser, highly persistent material) and methylene diphenyl di-isocyanate (MDI) (an allergen and sensitizer which is possibly carcinogenic to humans). Equally with MW there will be a change in risks, associated with accumulation of fibres in the body and the resin binder which is based on phenols and formaldehyde (formaldehyde is classified carcinogenic in the European Union - Carc. Cat. 3; R40)[83].

5.3.4 Production process

Table 5.13 sets out some details on the durability of the product and its ease during use.

[83] Note the these substances - MDI and formaldehyde - are intended to be consumed in the reaction process of making the product so it is only the residual, unreacted substance that may be a problem.

Table 5.13 Product durability and ease of use

Material	Description
Mineral wool (stone/rock, glass and slag wool)	When mineral wool is used for cavity wall insulation, it is deemed sufficiently stable, once installed, to remain an effective insulation material for the life of the building[84]. This is subject to water uptake which could result in sagging and loss of insulation properties. Personal protection equipment is likely to be required when handling and using mineral wool to avoid any possible skin irritations.
PUR/PIR	- PUR is less fire resistant than PIR[2] as it contains less methylene diphenyl di-isocyanate (MDI). PIR insulation products exhibit increased fire performance compared to PUR and reduced combustibility as well as higher working temperature limits[3]. - PUR and PIR insulation together have high compressive strength, are unaffected by air infiltration and are resistant to the passage of moisture. All of these attributes make them durable materials that retain their thermal properties over time. - In a number of low energy building designs, PUR and PIR show the lowest life cycle costs thanks to higher energy savings or, in the case of equal thermal resistance values (R-values), reduced material use and knock-on effects on the building. - The life cycle environmental performance of polyurethane (PU) insulation in low energy building designs is comparable to that of other common materials such as mineral fibre and EPS[85]. In some applications, this level of performance can even exceed that of mineral fibre and EPS[86].
EPS	- Thermoplastic polymer - EPS does not decompose. - According to the UK National Insulation Association (NIA), when EPS beads are used for cavity wall insulation, once installed, the bead filling in the cavity remains an effective insulation material for the life of the building and requires no further maintenance[87]. - EPS is used mostly at low densities so it saves fuel in transport. It is light, practical, safe and comfortable to handle and install and presents no dangers to health in installation and use. It does not cause scratching or irritation of the skin. Labour laws do not require gloves or masks to work with EPS. EPS is biologically inert and does not produce any pathogenic dust even in the long term. Thus EPS is safe for both installers and users[88].
XPS	- Thermoplastic polymer which is similar to EPS - Compared to EPS, XPS is thought to be a stronger material with higher mechanical performance[89].

84 http://www.nia-uk.org/householder/index.php?page=with-blown-mineral-wool

85 http://www.pu-europe.eu/site/

86 http://www.pu-europe.eu/site/fileadmin/Factsheets_public/Factsheet_15_Life_Cycle_Environmental_and_Economic_analysis_of_Polyurethane_Insulation_in_Low_Energy_Buildings__fin_.pdf

87 http://www.nia-uk.org/householder/index.php?page=with-e-p-s-beads

88 http://www.eumeps.org/

Use / performance

Table 5.14 presents embodied energy and carbon coefficients for mineral wool, EPS and PUR/PIR[89]. At first glance, it would apply that mineral wool and PUR/PIR have lower embodied energy to EPS and mineral wool has lower embodied CO_2 to EPS.

Table 5.14 Embodied energy and carbon of various insulation products

Material	Boundaries	Embodied energy (MJ/kg)	Embodied carbon (kg CO_2/kg)
Mineral wool	Cradle to gate	16.6	1.2
Stone wool (rock wool)	Cradle to site	16.8	1.05
Glass wool (fibreglass)	Cradle to site	28	1.35
PUR/PIR	Cradle to gate	72.1	3
EPS	Cradle to gate	88.6	2.5

Source: EC (2010)

Table 5.15 is however misleading as the embodied energy and carbon coefficients depend on the end-use application of the materials. For example, a product which requires less energy to produce may in practice need to be twice as thick as other products to achieve the desired thermal resistance. This is illustrated by the table 5.12 which presents different insulation materials' properties including embodied energy for a given thermal resistance of 3.3 m^2K/W when used for a 100 m^2 roof[89].

Table 5.15 Adjusted embodied energy figures of various insulation products

Type of insulation	Thermal conductivity (U-value) (W/m^2K)	Thickness (mm)	Weight (kg)	Total embodied energy (MJ)
Stone wool	0.038	127	1,520	33,622
Glass wool	0.037	123	1,295	44,807

[89] EC (2010) http://ec.europa.eu/environment/gpp/pdf/thermal_insulation_GPP_%20background_report.pdf

Type of insulation	Thermal conductivity (U-value) (W/m^{2}K)	Thickness (mm)	Weight (kg)	Total embodied energy (MJ)
PUR/PIR	0.024	80	264	33,317
EPS	0.035	117	291.6	28,933
XPS	0.036	120	420	46,284

Table 5.15 examines the different properties of the insulation for a given fixed level of thermal resistance and a specific building application context. This gives a more accurate account of how these materials perform against one another and more precise estimates of embodied energy per kg of insulation material. A comparison can therefore be made between various materials and EPS on the basis of the information in Table 5.12.

Based on Table 5.15 alternative materials to EPS are thought to have higher total embodied energy; stone wool (* 1.16), glass wool (* 1.55), PUR/PIR (* 1.15) and XPS (* 1.6). This is coupled with the fact that a higher mass (in kilogrammes) of stone wool, glass wool and XPS is required to achieve comparable thermal resistance to EPS (5.21, 4.44 and 1.44 times more respectively) whilst 0.91 times less PIR/PUR is required for this same thermal resistance value within the context of this specific building application. In terms of thermal conductivity, PUR/PIR is the only material with a lower and therefore better thermal conductivity value when compared to EPS[90]. It is worth noting, however, that mineral wool and XPS do not differ that much from EPS in this respect.

Table 5.16 provides a headline overview of known uses of each insulation product within building applications. It shows that EPS is a very versatile material within the building construction sector.

Table 5.16 Known end uses (buildings) for each insulation material

Material	Uses (building applications)
Mineral wool (stone/rock, glass and slag wool)	Wall insulation (e.g. masonry wall insulation, masonry cavity insulation, timber frame wall insulation, separating wall insulation , partition wall insulation), loft insulation, floor insulation (e.g. internal floor insulation, separating floor insulation), roof applications (e.g. loft insulation at joist level, flat roof insulation, roof insulation at rafter level), acoustic protection[10]

[90] Thermal conductivity is measured by the U-value. When this values is lower, it indicates that the rate of heat transfer through a building is lower and the insulate is effective

Material	Uses (building applications)
PUR/PIR	-PUR: cavity wall, roof, floor, pipe insulation, insulation of industrial installations[89] -PIR: metal faced panels, roof boards, cavity wall boards, pipe insulation[89]
EPS	Flat roof insulation, Pitched roof insulation, Floor insulation ‘slab-on-ground’ insulation, Insulated concrete floor systems, Interior wall insulation with gypsum board (doublage), Exterior wall insulation or ETICS (External Insulated Composite Systems), Cavity wall insulation boards, Cavity wall insulation loose fill, Civil engineering applications, Insulated concrete forms (ICF), Foundation systems and other void forming systems, Load bearing foundation applications, Core material for EPS used in sandwich and stressed skin panels (metal and wood fibreboard), Floor heating systems, Sound insulation in floating floors (to avoid transmission of contact sound), Seismic applications, EPS drainage boards, Perimeter and frost insulation, Core material in building blocks, Water filtration in filtration units, EPS/Concrete mixing[88].
XPS	-Similar to EPS - Insulation boards for roofing, flooring and wall applications in the construction sector[89].

5.3.5 End of life

Table 5.17 describes the various waste management options available for each insulation material following its end of life (typically the life of the building/structure).

Table 5.17 Waste management options available for each type of insulation product

Material	Waste management options
Mineral wool	- Stone wool: is made from volcanic rock, an increasing proportion of which is recycled in the form of briquettes. Furthermore, mineral wool manufacturers positively contribute to ‘industrial symbiosis’ (i.e. converting residual waste from one industry into raw materials for another) through the use of metallurgical slag, spent blasting sand and cullet (waste glass). Manufacturing processes have also been re-engineered to incorporate production scrap back into the primary production process, allowing 75% of glass wool production waste and 66% of stone wool waste to be recycled. In the case of some plants, it is even possible to recycle 100% of the insulation material[79]. - Mineral wool has no calorific value so there is no benefit to its incineration in terms of resulting energy**Error! Bookmark not defined.**
PUR/PIR	- Limited potential for reprocessing and recycling (none at present) - Long term disposal to landfill with potential dust emissions to air and surface water
EPS	- Residual dust and pellets from EPS can be resold (although this use is not being applied for).

Material	Waste management options
	- 100% of EPS can be recycled if it is recovered without contamination from other materials. - EPS is already one of the most widely recycled plastics and is collected through a European-wide network of collection points, organised both by local authorities and commercial enterprises with recycling rates of up to 70% (which is thought to be higher than recycling rates for MW). - Generally the most beneficial recycling option is direct re-use by grinding clean EPS waste and adding it to virgin material during production, which may be continued so long as it is at the same production site. EPS can be melted and extruded to make compact polystyrene, for items such as plant pots, coat hangers and wood substitutes. Medium toughened polystyrene from which sheets for thermoformed articles, such as trays, can also be made. As part of mixed plastic waste, EPS can be recycled to make park benches, fence posts and road signs, for example, ensuring the plastic material has a long and useful second life. This use is not supported in this application. -EPS can also be incinerated to recover its inherent energy content, with a calorific value of ~46MJ/kg. However, fire retardants in the material may hinder the melting process[80]. The calorific value of EPS available for heat recovery is slightly more than that of coal by weight. In a modern incinerator, EPS releases most of its energy as heat, aiding in the burning of municipal solid waste and emitting only carbon dioxide, water vapour and small traces of non-toxic ash. The fumes are said to be neither toxic nor harmful to the environment because of no dioxin or furan emissions. The energy gained can then be used for local heating and the generation of electricity.
XPS	-More potential for reprocessing and recycling than both PUR and PIR -XPS can easily be melted and re-pelletised if the product is not contaminated. It can also be thermally recovered[89].

5.3.6 Summary

Table 5.19 provides a summary of the advantages and disadvantages of each material competing to FR EPS.

Table 5.19 Summary of insulation materials relative to EPS

Material	Advantages compared to EPS	Disadvantages compared to EPS
Mineral wool (stone, glass slag)	• Makes use of waste and recycled material • No use of HBCDD (a PBT under REACH)	• Lower U value (thermal resistance) for a like for like building application • Stone and glass wool use 1.16 and 1.55 times more embodied energy in MJ/kg than EPS respectively. • Stone and glass wool uses 5.21 and 4.44 times more material (mass basis) for like for like building application

Material	Advantages compared to EPS	Disadvantages compared to EPS
		• On average mineral wool is more expensive (see section 5.2.4) • Thought to have a lower recycling rate compared to EPS
PU: PUR and PIR	• Lower U value (thermal resistance) for a like for like building application • PUR/PIR uses 0.91 times less material (mass basis) for like for like building application	• 1.15 times more embodied energy in MJ/kg used compared to EPS • Worse end of life performance: o Limited potential for reprocessing and recycling o Long term disposal to landfill with potential dust emissions to air and surface water • On average cost likely to be more expensive than EPS but not when adjusting for thermal performance (see section 5.2.4)
XPS	• Product: Stronger material with higher mechanical performance than EPS	• 1.6 times more embodied energy in MJ/kg used compared to EPS • XPS uses 1.44 times more material (mass basis) for like for like building application • Production process: requires more HBCDD than EPS to achieve the same fire performance standards.

5.4. Social impacts

5.4.1 Employment and skills

As set out in Table 2.18, there are 587 formulators of FR EPS who:

- directly employed 11,082 people; and
- indirectly employ 12,189 people

If it is possible for non-EU FR-EPS producers to supply a greater volume of their pellets to the EU (containing the pFR) and using HBCDD for non-EU customers (where possible to do so) then EU FR EPS formulators may continue to be able to make FR EPS in sufficient supply.

However, if there is a shortage of FR EPS in the EU and end users switch to another form of insulation material, then the most likely outcome is that, in the short term, production will be significantly scaled back. Since most FR EPS convertors specialise in making EPS only and a large proportion are SMEs, a significant shortage of FR EPS pellets available in the EU made with the pFR could potentially have a significant impact on their viability (in the short term and potentially in the long term too).

The scale of possible job losses could therefore be up to 10,000-20,000 and/or potentially lead to under-employment (where workers are retained as part time or reduced shift times). Some convertors may be able to switch part of the production/distribution effort to making XPS thereby minimising the overall impact of job losses. Additionally, a minority of convertors also make or distribute PUR/PIR/MW but this typically only currently accounts for <10% of their production.

The need for employees will increase once the pFR is available in sufficient quantities. The firing and hiring of employees (likely to be different people) could imply significant cost in terms of redundancy packages, and then hiring and training costs of new employees once there are sufficient quantities of the pFR. This could cost in the region of several hundred thousand euros.

Since manufacturing sites may not necessarily be located in the main cities, job losses are may have a more significant social impact within a local area as there are likely to be fewer opportunities for employment. It may also adversely affect (indirectly) induced employment in the area from reduced purchases of goods and services. Not only does this affect employment and disposable income for spend within the local economy, but a loss of jobs also means a loss of on-the-job skills and training available to EU workers.

It is difficult to estimate how long affected workers may be unemployed since there are no data on the relevant skills base of these workers and no employment statistics for the local area have been gathered (as it would be disproportionate to do so). However, in the context of the current economic conditions, it is possible that employment would not necessarily be restricted to temporary/short term.

The types of jobs likely to be lost include: a mixture of skilled manufacturing jobs, R&D activities as well as office, sales, marketing and site management related jobs (e.g. with health and safety and environment legislation).

Since at least in the short term a reduction in FR EPS available is expected to lead to increased demand for MW and PU, some of the job losses identified above could be replaced elsewhere in the EU (by different people) through increase shift/job creations associated with MW/PU production. Unless these insulation materials retain their increased market share (which is possible) these job creations will only be temporary/short term.

5.4.2 Consumer choice

In principle, consumers will still have the same choices with or without authorisation (i.e. they can still purchase FR EPS). But, in practice, the availability of FR EPS may be reduced. This could be problematic for the construction sector, businesses and households (e.g. who are building extensions, new buildings or retrofitting existing buildings) where planning permissions may have been granted subject to use of certain materials. Some businesses/households/builders may therefore have to re-apply or request a change in their application which may incur a financial cost as well as a resource cost (i.e. their time).

If such a situation occurs on a regular basis, this could have a negative impact on FR EPS demand as architects/surveyors as a precaution may adjust their designs/applications to avoid the use of FR EPS altogether.

5.5. Wider economic impacts

A net loss in EPS production, spending on goods and services and changes in employment could, in principle, have a short term macroeconomic impact in terms of a net loss per year in Gross Domestic Product (GDP) from reduced:

- manufacture of FR EPS in the EU;
- Spending on goods and services by the FR EPS supply chain; and
- Employment and increased costs in social welfare payments.

However, as noted in the economic and social impact sections (Sections 5.2 and 5.4), some of these production losses could be offset elsewhere in the EU economy through increased use of MW and PUR/PIR. Therefore a refused authorisation is unlikely to lead to any significant macroeconomic impacts at an EU level.

There may however be some redistribution within the EU economy with some Member States losing out (e.g. strong EPS production) and other gaining (e.g. strong MW/PUR/PIR production). For example Poland (215), Germany (76), Czech Republic (46), Romania (44) and Italy (35) have a significant number of EPS manufacturing sites that would be particularly affected (especially the SME firms who specialise in FR EPS production) in terms of jobs and output (i.e. components of GDP) (see Table 2.18).

5.6. Comparison of costs and benefits

Table 5.20 summarises the main costs and benefits associated with a refused authorisation for "use 2 – manufacture of articles from FR EPS". Note that some impacts are not monetised so monetary impacts are presented alongside qualitative and quantitative impacts[91].

Table 5.20 Main costs and benefits of a refused authorisation for "use 2" (2015-2019)

Type of impact	Costs of a refused authorisation for "Use 2"	Benefits of a refused authorisation for "Use 2"	Net impact
Economic	Lost sales to EU FR EPS convertors: €113m (PV 2015-2019) Higher cost to consumers: up to €750m (PV 2015-2019)	Increased sales to EU producers of MW, PUR/PIR, XPS – This could potentially offset any cost sales to FR EPS producers (formulators and convertor)	Net economic cost to consumers of up to €750m (PV 2015-2019)
Human health	There are potentially some health risks associated with the production and use of other insulation materials. In practice these are likely to be minimal.	No impacts on human beings via the environment as exposure is below threshold so no reproductive toxicity effects expected	No significant change in human risks
Environ-mental	Possible increase in transportation emissions (e.g. CO_2, NOx, SO_2, and PM) from FR EPS being imported into the EU Alternative materials to EPS have a higher embodied energy in MJ/kg	Additional HBCDD released to the environment considered to be very low from continued use for 4 years. Total releases to the environment over 4 year of up to 1.98 tonnes of which 84% of the HBCDD released is either degraded in the environment within the four year period or removed in sewage treatment (and then incinerated or landfilled). Up to 190kg may be found in freshwater and marine sediment and up to 130kg found in soil.	Very small improvement in HBCDD released to the environment of up to 1.98 tonnes over 2015-2019 for use 1 and 2
Social	Between 10,000-20,000 jobs could be at risk in the short term if EU convertors do not have sufficient supply	Increased short term employment from EU producer of MW, PUR/PIR, XPS. The extent to which these displace EPS job losses may depend on the scale of any increase in FR EPS being imported into the EU	Likely to be significant net loss in jobs within the EU
Macro-economic	Reduced EU sales revenue (contribution to GDP) and worse EU trade balance from increased imports and reduced exports	Increased sales to EU producer of MW, PUR/PIR, XPS – This could potentially offset any cost sales to FR EPS producers (formulators and convertor)	No significant change in macroeconomic impacts

Notes: Present value (PV) calculated using a 4% discount rate in accordance with REACH SEA guidance (2011).

[91] The qualitative assessment of the some impacts largely reflects the common principle in socio-economic analyses of ensuring a proportional analysis is undertaken for the scope and scale of impacts being appraised.

Based on the cost-benefit analysis summarised in Table 5.20, it is evident that overall society would be worse off if authorisation for the continued use of HBCDD to make articles (EPS boards and beads) using FR EPS pellets was refused. This is due to an increased cost to consumers from switching to other insulation materials (€113million PV over 2015-2019), which is likely to outweigh the estimated net environmental benefit of reducing HBCDD of up to 190kg in freshwater and marine sediment and up to 130kg in soil (from uses 1 and 2).

As it is not possible to put a monetary value of up 1.98 tonnes of HBCDD in the environment, it is worth examining it from a cost per tonne perspective. The cost of a refused authorisation for use 2 is estimated at €56,970/kg of HBCDD avoided into the environment (€57million/tonne) and even higher for actual releases that end up in freshwater, marine sediment or soil at €352,504/kg avoided (i.e. excluding those removed from treatment or degraded) (€353million/tonne).

In order to put these costs per tonne into perspective, it is again worth referring to Figure 4.14 which showed estimates of EU average damage costs per tonne emitted for a number of different air pollutants (which is an area where it has been possible to value impacts). It shows that costs per tonne range from several euros per tonne (CO_2) to around a million per tonne for lead, mercury and PAHs.

Therefore estimates of either; €57million/tonne and €353million/tonne (for HBCDD) are significantly higher making it clear that even if the benefits to the environment were estimated that the benefits of a refused authorisation would not outweigh the costs. The €/t figures are also based on worst case estimates (in terms of releases to the environment) as it assumes the applicants only use HBCDD for an additional four years but as noted earlier, consortium members are committed to switching to the pFR as soon as possible and in practice will use some pFR and HBCDD over this period with the intention to completely phase out use of HBCDD by 2019 (sooner if possible). The cost per tonne figures would therefore be around three times higher if it were based on just the expected volume of HBCDD used over 2015-2019.

Non-monetised impacts do not change this conclusion because no there is no significant change in risk to human health, social and macro-economic impacts.

6. CONCLUSIONS

HBCDD was prioritised for authorisation by ECHA due to the wide dispersive uses of end products containing HBCDD and the high volumes and the potential releases over the full life-cycle of articles and preparations. HBCDD has been placed on Annex XIV of the REACH Regulation. Consequently, a granted authorisation is required for the continued use of the substance beyond the sunset date of 21/08/2015. For an authorisation application to be assessed, by ECHA an application for authorisation must be submitted to ECHA before 21/02/2014.

The two uses of HBCDD that the applicants are seeking authorisation for are:

1. Use 1: "Formulation of flame retarded expanded polystyrene (EPS) to solid unexpanded pellets using hexabromocyclododecane as the flame retardant additive (for onward use in building applications)"; and

2. Use 2: "Manufacture of flame retarded expanded polystyrene (EPS) articles for use in building applications".

The applicants are committed to completely switch from HBCDD to the pFR as soon as possible over the period 2015-2019. The applicants therefore only seeking a "bridging period" authorisation for continued use with a 4-year review period (i.e. review in 2019). By 2019, there will be certainty over whether it is possible to completely replace HBCDD with a possible polymeric FR (pFR) alternative for uses 1 and 2 in terms of its technical suitability and its availability in sufficient supply.

An authorisation with a 4-year review period would also allow the REACH Regulation, which covers the European Union (EU) region, to align itself with the Stockholm Convention on Persistent Organic Pollutants (POPs) which covers most parts of the world. According to the Sixth Conference of Parties in May 2013 (EC 2013)[92], HBCDD has been recommended to be included on Annex A of the Stockholm Convention on Persistent Organic Pollutants (POPs). This would lead to an international ban on the production, placing on the market and use of HBCDD in, HIPS and textiles as well as non-building-related applications of EPS and XPS.

A bridging authorisation is being requested to continue to use HBCDD in FR EPS by pellet producers for 4 years for the period 2016-2020 to avoid:

- A situation where there is insufficient supply of the polymeric alternative to meet total demand for EPS production (and XPS production);

[92] (EC 2013) - Proposal for a COUNCIL DECISION on the position to be adopted, on behalf of the Europe Union, at the Sixth Conference of the Parties to the Stockholm Convention on Persistent Organic Pollutants with regard to the proposal for an amendment of Annexes A and B. Available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2013:0134:FIN:EN:PDF

- An anti-competitive situation within the EPS market whereby some buyers have supply of the polymeric alternative before others;
- A situation where Member States have not approved the use of the polymeric alternative as a flame retardant in EPS that meets stringent fire safety requirements;
- A loss in market share where there has not been sufficient time to establish market confidence in EPS with the polymeric alternative; and
- To avoid limiting production to non FR EPS because this would not be economically viable. It could lead to plant closures and the loss of jobs as non-FR EPS would not be able to meet fire regulations limiting its applications within construction applications.

The industry has been investigating possible alternatives to HBCDD for a long time as determined in the AoA, and has been proactive in trying to minimise risks which can be seen through results in the SECURE programme (see the CSR and AoA for further details). The applicants are therefore seeking time to phase in the polymeric alternative in a timely manner that preserves the market share that EPS has developed over the last 40 years.

Should authorisation be refused, the initial analysis of alternatives (AoA) indicates that there are no suitable alternatives for EPS producers available. Therefore, a refused authorisation is likely to result in significant economic costs to the EU FR EPS supply chain.

In Section 4 (See Table 4.4) and Section 5 (see Table 5.20), it was shown that, in isolation, society is worse off if authorisation is refused for either use 1 or use 2. Given the interdependent nature of the two uses being applied for, Table 6.1 also summarises the results which have been deliberately estimated to avoid the double counting of the various impacts considered.

Based on the cost-benefit analysis summarised in Table 6.1, it is evident that society overall would be worse off if authorisation were refused for the continued use of HBCDD to make FR EPS. This is due to the significant net economic impact of between €750million and €1,175million (in present value terms). This impact outweighs the estimated net environmental benefit of reducing HBCDD of up to 1.98 tonnes into the environment; of which 190kg is in freshwater and marine sediment and up to 130kg in soil (from uses 1 and 2).

Table 6.1 Main costs and benefits of a refused authorisation for "Uses 1 and 2" (2015-2019)

Type of impact	Costs of a refused authorisation	Benefits of a refused authorisation	Net impact
Economic	Lost sales to EU FR EPS pellet producers: €1,175m (PV 2015-2019)	Increased sales to EU producers of MW, PUR/PIR, XPS – This could potentially offset all lost sales to FR EPS producers (formulators and convertor) resulting only in a net cost to the consumer. If lost EU EPS sales are displaced by increase sales from imports of FR EPS (using pFR) then there is no net cost to consumers or to formulators (but still a cost to FR EPS formulators).	Net economic cost of €750m - €1,175m (PV 2015-2019)
	Lost sales to EU FR EPS convertors: €113m (PV 2015-2019)		
	Higher cost to consumers: up to €750m (PV 2015-2019)		
Human health	Increased transportation emissions (e.g. CO_2, NOx, SO_2, and PM) from FR EPS being imported into the EU may lead to respiratory impacts to humans from increased emissions of air pollutants	No impacts on human beings via the environment as exposure is below threshold so no reproductive toxicity effects expected	No significant change in human risks
	There are potentially some health risks associated with the production and use of other insulation materials. In practice these are likely to be minimal.		
Environ-mental	Possible increase in transportation emissions (e.g. CO_2, NOx, SO_2, and PM) from FR EPS being imported into the EU	Additional HBCDD released to the environment considered to be very low from continued use for 4 years. Total releases to the environment over 4 year of up to 1.98 tonnes of which 84% of the HBCDD released is either degraded in the environment within the four year period or removed in sewage treatment (and then incinerated or landfilled). Up to 190kg may be found in freshwater and marine sediment and up to 130kg found in soil.	Very small improvement in HBCDD released to the environment of up to 1.98 tonnes over 2015-2019 for use 1 and 2
	Alternative materials to EPS have a higher embodied energy in MJ/kg		
Social	Up to 500 jobs could be at risk in the short term from reduced FR EPS formulation	Increased short term employment from EU producer of MW, PUR/PIR, XPS. The extent to which these displace EPS job losses may depend on the scale of any increase in FR EPS being imported into the EU	Likely to be significant net loss in jobs within the EU
	Between 10,000-20,000 jobs could be at risk in the short term if EU convertors do not have sufficient supply of FR EPS pellets		
Macro-economic	Reduced EU sales revenue (contribution to GDP) and worse EU trade balance from increased imports and reduced exports	Increased sales to EU producer of MW, PUR/PIR, XPS – This could potentially offset any cost sales to FR EPS producers (formulators and convertor)	No significant change in macroeconomic impacts

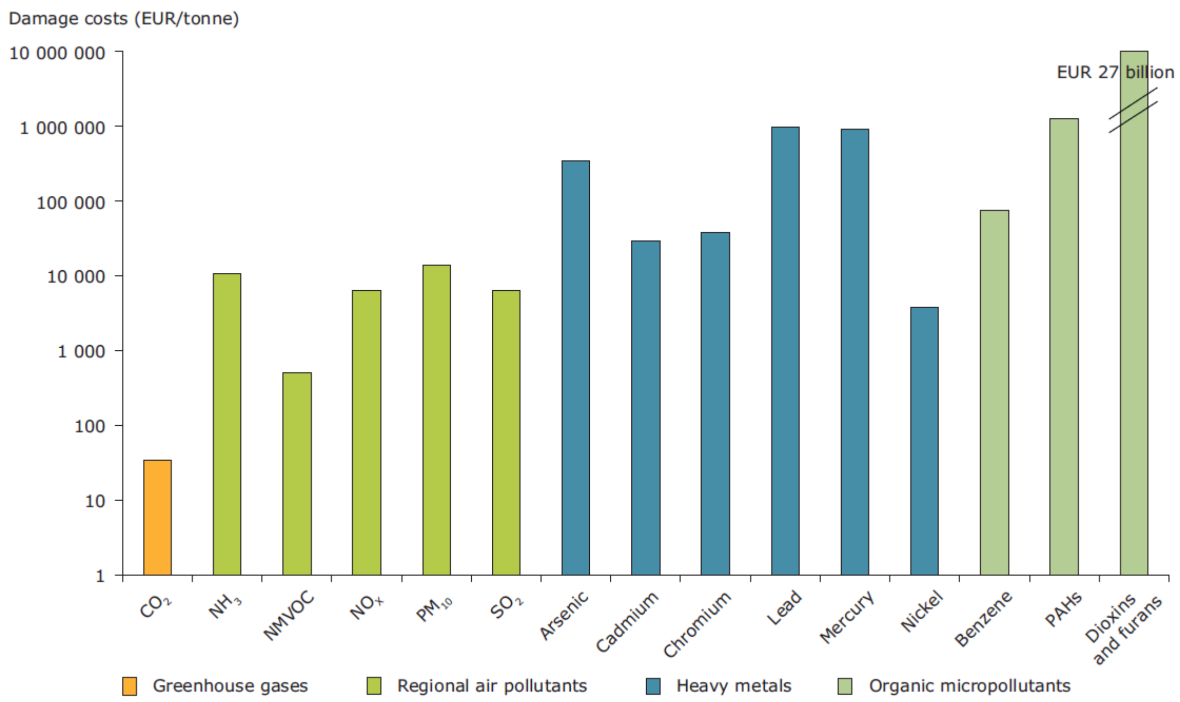
Notes: Present value (PV) calculated using a 4% discount rate in accordance with REACH SEA guidance (2011).

As it is not possible to put a monetary value of up 1.98 tonnes of HBCDD in the environment, it is worth examining it from a cost per tonne perspective. The net cost of a refused authorisation is estimated at to be:

- Between €379m/tonne (=750million/1.98) and €594million/tonne (=1175/1.98) of HBCDD avoided into the environment; or
- Between €2,343million/tonne (=750million/0.32) and €3,673million/tonne (=1175/0.32) of HBCDD avoided which ends up in freshwater, marine sediment or soil (i.e. excluding those removed from treatment or degraded).

In order to put these costs per tonne into perspective, Figure 6.1 (same as Figure 4.14) shows estimates of EU average damage costs per tonne emitted for a number of different air pollutants (which is an area where it has been possible to value impacts). It shows that costs per tonne range from several euros per tonne (CO_2) to around a million per tonne for lead, mercury and PAHs.

Figure 6.1 Estimates of the European average damage cost per tonne emitted for selected air pollutants



Source: EEA (2011)

Therefore estimates of between €379million/tonne and €3.7billion/tonne (for HBCDD) are significantly higher making it clear that even if the benefits to the environment were estimated that the benefits of a refused authorisation would not outweigh the costs. The €/t figures are also based on worst case estimates (in terms of releases to the environment) as it assumes the applicants only use HBCDD for an additional four years but as noted earlier, consortium members are committed to switching to the pFR as soon as possible and in practice will use some pFR and HBCDD over this period with the intention to completely phase out use of HBCDD by 2019 (sooner if possible). The cost per tonne figures would therefore be around three times higher if it were based on just the expected volume of HBCDD used over 2015-2019.

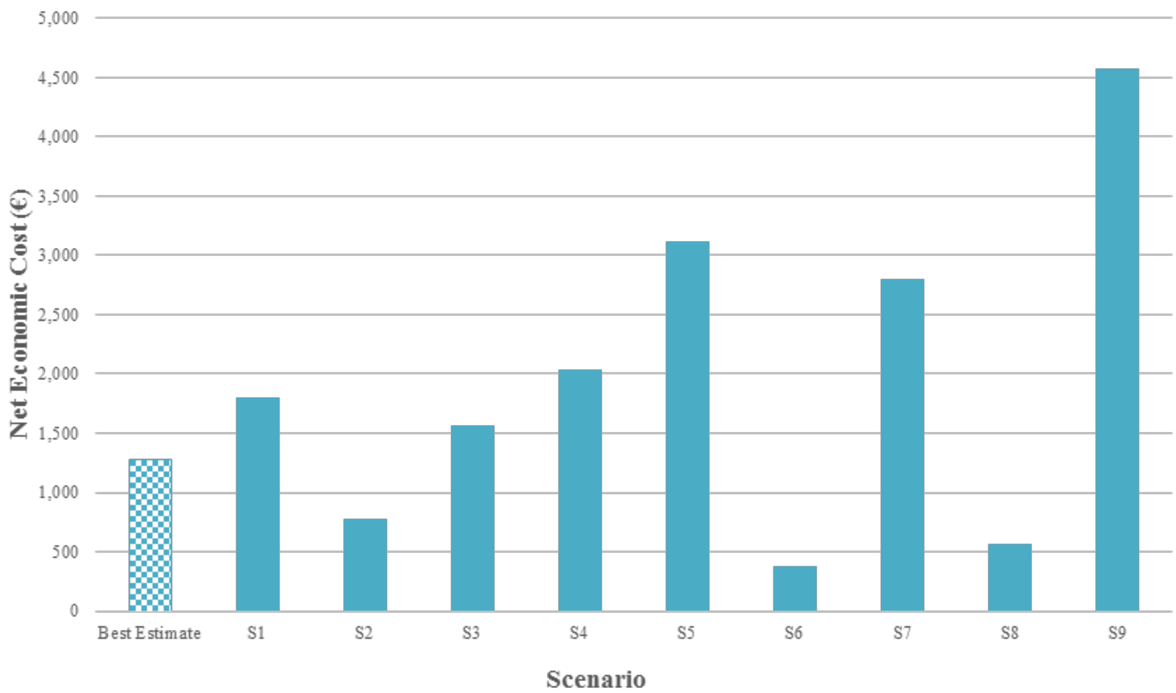
Non-monetised impacts do not change this conclusion because no significant change in risk to human health is identified, whilst the social and macro-economic impacts are judged to reinforce the net economic loss.

Uncertainty analysis

In the SEA report, Table 4.1 estimates that the economic cost to FR EPS pellet manufacturers from lost production would be €1,175million (PV 2015-2019) and Table 5.1 estimated the total loss at €113million (PV 2015-2019) for FR EPS convertors. The total loss of ~€1.29billion (over 4.5 years) results from a shortage in supply of the pFR relative to forecasted demand. The calculations of economic costs were based on several variables: some of which are known with certainty, while others are not (but based on expert judgement).

It is noted throughout the report that there are significant uncertainties related to supply and demand of the pFR. Appendix G undertakes sensitivity analysis through nine scenarios varying assumptions/variables used for calculating economic costs. Figure 6.2 summaries the results with further details included in Appendix G. The analysis shows that all scenarios result in a net cost and how they compare relative to the best estimate (€1.29billion).

Figure 6.2 Economic costs under the 9 sensitivity analysis scenarios



The sensitivity analysis does help to highlight there is significant business uncertainty around sufficient supply of the pFR relative to demand. The results indicate that these changes to key variables have a significant effect on the headline number, with the net economic cost value rising as much as 255% or falling by 70%, relative to the current €1.29billion estimate. However in all cases there is a net cost due to insufficient supply relative to demand.

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APPENDIXES AND ANNEXES

APPENDIX A: CONFORMITY WITH ECHA TEMPLATE

The purpose of this checklist is to demonstrate to the SEA Committee that their SEA reporting covers all of the necessary content that is identified in the ECHA SEA template.

Table A.1 ECHA SEA template checklist (Use 1)

	Assessed in this report	Section
1.1 Aims and scope of SEA	Yes	1
1.2 Definition of applied for use scenario	Yes	2
1.3 Definition of non-use scenario	Yes	4.2
2.1 Human health and environmental impacts	Yes	4.3-4.4 and 5.3
2.2 Economic impacts	Yes	4.2 and 5.2
2.3 Social impacts	Yes	4.5 and 5.4
2.4 Wider economic impacts	Yes	4.6 and 5.5
3.1 Comparison of impacts	Yes	4.7 and 5.6
3.2 Distributional impacts	Yes	Within 4
3.3 Uncertainty	Yes	Throughout. Also Appendix G
4 Summary and conclusions	Yes	6

APPENDIX B: PRESS RELEASES ABOUT SUPPLY OF THE PFR

The following table outlines the main findings from a search of press releases on the production of the pFR issued by three known leading manufacturers: Albermale, Chemtura and ICL-IP.

Table B.1 Information about the supply of pFR from press releases

Company and commercial name for pFR	Date of press release	Information released	Implications for timescale of supply of pFR
Albemarle pFR marketed as GreenCrest™	21/05/2012[93]	• Albemarle announces the manufacture of the pFR marketed under the trade name GreenCrest™. • Albemarle plans to commercialise the pFR by 2014. • Production site for the pFR is still not confirmed at this stage.	• The pFR will be made commercially available by 2014.
	06/12/2012[94]	• Albemarle announces plans to expand its manufacturing operations to support growing demand in all three of its global business units and the manufacture of a new line of sustainable fire safety solutions. • The expansion will occur from 2012 – 2016 and will add facilities to manufacture two new products one of which is the pFR. • Albemarle proceeding with the expansion project is subject to final approval by the local county council where the plant is based.	• 5 months between announcement of plans to commercialise the pFR by 2014 and official announcement of expansion of manufacturing operations. • Possible potential future delay due to process of getting final approval from local county council for expansion of manufacturing operations.

[93]http://investors.albemarle.com/phoenix.zhtml?c=117031&p=irol-newsArticle&ID=1697942&highlight=Greencrest

[94]http://investors.albemarle.com/phoenix.zhtml?c=117031&p=irol-newsArticle&ID=1765245&highlight=greencrest

Company and commercial name for pFR	Date of press release	Information released	Implications for timescale of supply of pFR
	11/04/2013[95]	• Albemarle announces that it expected to begin to supply the pFR for commercial qualification in insulation applications by mid-year 2013, as scheduled. • Previously, Albemarle completed lab scale qualification to the market with favourable results. • Within 24 months of successful completion of commercial qualification, Albemarle expects to have the pFR available for commercial sale.	• Announcement of production for commercial qualification ahead of the expected date at which the pFR is supposed to become commercially available (i.e. 2014). • Although the pFR is expected to be available for commercial qualification by mid-2013, no further announcements or updates, as of July 2013, have been given. • Assuming the commercial qualification process of the pFR happens according to schedule (which it hasn't), a further 24 months of successful completion of commercial qualification will be required before the pFR becomes commercially

[95] http://investors.albemarle.com/phoenix.zhtml?c=117031&p=irol-newsArticle&ID=1806038&highlight=crest

Company and commercial name for pFR	Date of press release	Information released	Implications for timescale of supply of pFR
			available. This means the pFR will not be commercially available until mid-2015 assuming no delays.
Chemtura (Great Lakes Solutions) pFR marketed as Emerald Innovation™ 3000	29/03/2011[96]	• Chemtura Corp. signs a license agreement with the Dow Chemical Company for the pFR technology for use EPS/XPS insulation. • The business is running an interim facility producing quantities for plant-scale qualifications. • The Dow Chemical Company also announced on 29/03/201197 that it is expected that: • pFR licensees will have interim quantities available throughout 2011 to enable market qualifications. • This will be followed, likely in 2012, by large plant construction by the licensees, making significantly larger commercial volumes available by 2013-2015 that are in line with the current HBCDD market demand.	• Quality control of the pFR begins in March 2011. • Possible expansion of production to increase the availability of the pFR by 2013-2015 in line with current HBCDD market demand.
Chemtura (Great Lakes	03/05/2011[98]	• Press release formally introduces the pFR to relevant users.	• Quality control of the pFR which began in March

[96] http://www.greatlakes.com/pdf/news/Great%20Lakes%20Solutions_TDCC%20Licensee%20PR_FINAL.pdf

[97] http://www.dow.com/licensing/news/2011/20110329a.htm

[98] http://www.greatlakes.com/pdf/news/Great%20Lakes%20Solutions_Emerald%203000_name%20release%20_050311.pdf

Company and commercial name for pFR	Date of press release	Information released	Implications for timescale of supply of pFR
Solutions) pFR marketed as Emerald Innovation™ 3000		• To meet increasing demand for plant-scale qualifications, capacity has been expanded in the company's interim production facility. • Many customers have requested large-scale samples in order to qualify the product.	2011 is still ongoing.
	20/11/2012[99]	• Announcement of the initiation of commercial production of the pFR.	• Initiation of commercial production of pFR is announced 1 year and 8 months after original quality control began in March 2011.
	22/04/2013[100]	• Confirmation of commercial production at nameplate capacity of at least 10,000 metric tons. • Sales of the pFR commenced in Q4 2012. • In addition to great success in Europe, customer qualifications are accelerating both in the Americas in Japan. • Possible expansion scenarios are being explored to build upon the early adoption of this critical innovation and ensure suitable supply for a growing industry.	• Commercial production of at least 10,000 metric tons is confirmed 5 months after announcement of initiation of commercial production and almost 23 months after the start of customer qualifications.

[99] http://www.greatlakes.com/pdf/news/Emerald-Innovation-3000-Commercialization-Press-Release.pdf

[100] http://www.greatlakes.com/pdf/news/Great%20Lakes%20Solutions%20Sees%20Continued%20Success%20with%20New%20Flame%20Retardant%20Technology_April%2022%202013.pdf

Company and commercial name for pFR	Date of press release	Information released	Implications for timescale of supply of pFR
ICL Industrial Products pFR marketed as FR-122P	25/01 /2012 [101]	• Announcement that ICL-IP signs a licensing agreement with Dow Global Technologies (LLC) a subsidiary of the Dow Chemical Company for its pFR technology. • The company expected to begin supplying commercial quantities beginning in 2014; and is currently supplying pilot quantities as required to its customers. • ICL-IP has already begun work on a new 10,000-metric-ton capacity manufacturing plant.	• ICL-IP signs a license agreement with the Dow Chemical Company 10 months after Chemtura does the same.
	28/05 /2013 [102]	• ICL-IP is expecting to be able to meet the needs of polystyrene foam producers for the pFR in making the transition from HBCDD to a more sustainable alternative.	

[101] http://icl-ip.com/?news=icl-ip-ensures-its-leading-position-in-flame-retardants-with-new-eco-friendly-polymeric-offering

[102] http://icl-ip.com/wp-content/uploads/2013/05/UNEP-HBCD.pdf

APPENDIX C: QUESTIONNAIRE USED WITH EPS PELLET PRODUCERS

AUTHORISATION APPLICATION SUPPORT INCLUDING SOCIO-ECONOMIC ANALYSIS FOR HEXABROMOCYCLODODECANE (HBCDD)

Initial list of data required from EPS members for scoping study

Following the kick-off meeting (25/07/2012) with the EPS consortium, it was agreed that the technical service providers (PFA and eftec) will provide Philippe Marechal with an initial list of data needed, as he will should have similar information available from a number of studies commissioned by Plastics Europe.

Based on a rapid assessment of information provided to date, the following table sets out data required from each consortium member for this study. As discussed during the meeting, this information should be sent by email to ReachCentrum (Leo Appelman) and should not be sent to other consortium members.

We would kindly request members provide as much data as possible by the **28th of September (at the latest)** in order for the information to be incorporated into the scoping report (17th October). If certain information cannot be provided before the 28th September, we would appreciate if you could indicate if it is feasible to provide this information and by when. This will allow us to coordinate next steps for the full study.

Company information	
Company name:	
Company contact: (name and email) concerning data provided	
Number of plants in the EU:	
Location of EU plants: (e.g. Netherlands, France, Germany)	
Number of plants outside of the EU:	

Data needed from each consortium member						
Information about upstream supply						
1) How much HBCDD have you used each year over the past five years? (tonnes/year)		**2007**	**2008**	**2009**	**2010**	**2011**
2) How much HBCDD do you expect to use each year over the next five years? (tonnes/year)		**2012**	**2013**	**2014**	**2015**	**2016**
3) How much Styrene, Pentane and Peroxide have been purchased? (tonnes per year over a 5 year period) *Published list prices is fine*		**2007**	**2008**	**2009**	**2010**	**2011**
	Styrene					
	Pentane					
	Peroxide					
a) How many are from EU based companies? (~% if known)	Styrene	%				
	Pentane	%				
	Peroxide	%				
4) What is the average cost of these raw materials? (~€/t for each material) *If there are significant fluctuations please provide a low-high range.*		**Low cost**		**Average cost**	**High cost**	
	Styrene					
	Pentane					
	Peroxide					

<table>
<tr><th colspan="7">Data needed from each consortium member</th></tr>
<tr><th colspan="7">Information about EPS bead production</th></tr>
<tr><td colspan="2" rowspan="2">5) How much <u>fire retardant</u> EPS beads do you produce? (tonnes/year over 5 year period)</td><td>2007</td><td>2008</td><td>2009</td><td>2010</td><td>2011</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2" rowspan="3">6) Do you expect <u>fire retardant</u> EPS beads production to change over the next 5-10 years (compared to last five years? (and why)</td><td>2012</td><td>2013</td><td>2014</td><td>2015</td><td>2016</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="5">Rational:</td></tr>
<tr><td colspan="2">7) How efficient (%) is your on-site wastewater/sewage treatment plant at removing HBCDD from any wastewater released?</td><td colspan="5"></td></tr>
<tr><td colspan="2">8) Where is wastewater released to? (e.g. what river basin)
• What is the annual concentration (mg/l) of HBCDD in wastewater and volume (kg) released per year? (5 year record)</td><td colspan="5"></td></tr>
<tr><td colspan="2">9) What are the annual emissions of HBCDD to air for past 5 years? (t/year and concentration in mg/m³)</td><td colspan="5"></td></tr>
<tr><td rowspan="3">10) How much waste (kg) is produced each year which may contain HBCDD? (5 year record)

• What happens to the waste which may contain HBCDD? (E.g. is sludge / filter cakes sent to landfill, incineration, etc.)</td><td></td><td>2007</td><td>2008</td><td>2009</td><td>2010</td><td>2011</td></tr>
<tr><td>Volume</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Destination</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">11) Monitored data of occupational exposure levels to HBCDD? (dermal and inhalation)</td><td colspan="5">(attach as a separate note if required)</td></tr>
</table>

Data needed from each consortium member						
12) How many people are directly employed from EPS production and its maintenance? (production purpose only)						
13) How many people are indirectly employed? (E.g. research, sales, marketing, distribution etc.)						
Information about EPS bead market						
		2007	**2008**	**2009**	**2010**	**2011**
14) How much <u>fire retardant</u> EPS beads do you sell to each end use? (tonnes/year over 5 year period)	Insulation boards					
	Insulation blown beads					
	Packaging					
	…(others)					
	TOTAL					
15) Average value of <u>fire retardant</u> EPS beads sales (~€/t for each end use)	Insulation boards					
	Insulation blown beads					
	Packaging					
	…(others)					
16) How do we expect the market to change over time? (next 5-10 years)						

Data needed from each consortium member	
17) Approximately how many customers (convertors to make EPS boards) do you sell fire retardant EPS to per year? (5 year record)	
Information about R&D activities	
18) Provide a summary of what R&D activities have been carried out in the past in relation to alternatives	*(attach as a separate note if required)*
19) Provide a summary of the key findings of R&D to date on alternative	*(attach as a separate note if required)*
20) Approximate expenditure spent on R&D on alternatives (€/year)	

APPENDIX D: HAZARD AND EXPOSURE INFORMATION

The information set out in this appendix is a supplement to section 2.9 of this report and considered information both from the EURAR and CSR on exposure levels for HBCDD from the manufacture and use of flame retarded EPS.

D.1 Environmental hazards of HBCDD

The EURAR describes the notional safe level for the aquatic compartment (the predicted no effect concentration 'PNEC') for both freshwater and aquatic sediment, as follows:

- For freshwater this is 0.31 µg/l
- For freshwater sediment this is 0.86 mg/kg sediment dry weight (dwt).

The risk assessment also calculated the predicted environmental concentration (PEC), this is the concentration that is estimated to be found for a particular use pattern in different environmental compartments. If the PEC is greater than the PNEC, i.e. the concentration in a compartment is estimated to be greater than the notional safe level then there is a risk that needs to be controlled.

EU RAR for specific sites and for a generic scenario describing EPS formulation led risk for freshwater and sediment as shown in Table D.1.

Table D.1 PNEC and PEC for the aquatic compartment from the EU Risk Assessment

Compartment	PNEC	PEC	PEC/PNEC ratio[103]
Freshwater	0.31 µg/l	0.76 µg/l	2.45
freshwater sediment	0.86 mg/kg sediment dwt	3.5 mg/kg dwt	4.07

The section 9 of the CSR shows PECs that would not lead to a risk compared with the same PNEC for water, as shown in Table D.2.

Table D.2 PNEC and PEC for the aquatic compartment comparing PNEC from EU RAR with PEC from CSR Section 9

Compartment	PNEC	PEC	RCR
Freshwater	0.31 µg/l	0.0426 µg/l	0.14

[103] The ratio of PEC to PNEC in the EU RAR is now known as the risk characterisation ratio (RCR) in REACH.

freshwater sediment	10 mg/kg sediment dwt	0.168 mg/kg dwt*	0.02

*Reported in the CSR as 0.0421 mg/kg wet weight – assumed ratio wet to dry weight is 0.2 solid to 0.8 water, but also depends upon adjustment for organic carbon (because we do not have access to the CSR we cannot see what has been done by the registrant).

The EU RAR (EC 2008) assessed available data at the time in order to define the hazard to the environment. These data comprised test data on animals and plants that are deemed to be representative of different environmental compartments and also of different trophic levels[104].

The data were used to define the safe level for different environmental compartments; this is done by application of an assessment factor that accounts for the uncertainty in the data set and the extrapolation from species to sets of species or from one compartment to anther or from short to long term effects for example. The safe level is referred to as the predicted no effects concentration 'PNEC'. The set of PNECs defined in the EU RAR are shown below in Table D.3.

Table D.3 Environmental hazard characterisations from the EU RAR

Environmental hazard characterisations from the EU RAR				
Compartment	Effect level and species	Assessment factor	Predicted no effect concentration (PNEC)	Value and resultant PNEC used in CSR (where different from EURAR)
Aquatic (freshwater)	NOEC 3.1 µg/l *Daphnia magna*	10	0.31 µg/l	
Intermittent release, aquatic environment	EC50: 52 µg/l *Skeletonema costatum*	10	0.52 µg/l	
Marine environment	NOEC: 3.1µg/l *Daphnia magna*	100	0.03 µg/l	
Intermittent release, marine environment	EC50: 52 µg/l *Skeletonema costatum*	100	0.05 µg/l	
Sediment	NOEC: 8.6 mg /kg dwt *Lumbriculus variegatus*	10	0.86 mg/kg dwt	*Hyalella azteca* 28 day NOEC ≥1000 mg/kg; PNEC: 10 mg/kg dwt
Sediment, marine	NOEC: 8.6 mg/kg dwt	50	0.17 mg/kg dwt	

[104] Tropic levels are the different levels of ecological organisation that make up and ecosystem, from 'primary producers' – plants, through to top predators such as fish eating birds

Environmental hazard characterisations from the EU RAR				
Compartment	Effect level and species	Assessment factor	Predicted no effect concentration (PNEC)	Value and resultant PNEC used in CSR (where different from EURAR)
Environment	*Lumbriculus variegatus*			
Micro-organisms in STP	EC30: 15 mg/l	10	0.15 mg/l	
Atmospheric Compartment	Not derived	-	-	
Terrestrial Compartment	NOEC: 59 mg/kg dwt Earthworms (*Eisenia fetida)*	10	5.9 mg/kg dwt	
Non compartment specific effects (secondary poisoning)	NOAEC: 150 ppm Rats	30	5.0 mg/kg food	Repeated dose oral NOAEL of 1000 mg/kg - RAT PNECoral 222.2 mg/kg food

The specific information used in the RAR may be used to build up a picture of environmental effects and could be useful for attempting to describe the possible impacts on the environment from exposure to HBCDD. The set of reliable data from testing that was used to derive the PNECs used in the EU RAR to define the environmental hazard profile of HBCDD is set out below in Table D.4. The information presented in this table may be important in order to build up a picture in the full SEA study of the type of impacts that might be expected in the environment from concentrations of HBCDD.

Table D.4 Environmental hazard data from the EU RAR

Environmental hazard data from the EU RAR		
Compartment/Species	Results	Test
FISH		
Acute toxicity		
Onchorhyncus mykiss	No mortalities or other effects around 2.5 µg/l.	OECD 203 and TSCA 40/797/1400, and ASTM Standard E729-88a
Chronic toxicity		

Environmental hazard data from the EU RAR		
Compartment/Species	Results	Test
Rainbow trout (*Oncorhynchus mykiss*)	NOEC µg/l Hatching success ≥3.7 Swim-up ≥3.7 Larvae and fry survival ≥3.7 Growth ≥3.7	Flow-through OECD 210 and OPPTS 850.1400
INVERTEBRATES		
Acute toxicity		
Daphnia magna	48 h EC_{50} >3.2 µg/l	OECD 202. Static immobilisation test, and TSCA 40/797/1300, and ASTM Standard E729-88a
Chronic toxicity		
Daphnia magna	**NOEC 3.1 µg/l** LOEC length 5.6 µg/l	TSCA , OECD Flow through 21 day test.
ALGAE		
Selenastrum *Capricornutum*	96 h EC_{50} >2.5 mg/l	OECD 201 and TSCA40/797/1050
Skeletonema costatum *Thallassiosira pseudonana* *Chlorella sp.*	72 h EC_{50} = 9 µg/l (lowest value) 72 h EC_{50} = 40 µg/l (lowest value) 96h EC_{50} >water solubility	Marine algal bioassay method, different marine growth media
Skeletonema costatum	NOEC <40.6 µg/l EC_{50} >40.6	OECD 201, ISO 10253:1995 and EU Directive 92/69/EEC – Method C.3
Skeletonema costatum	NOEC >10 µg/l EC_{50} **52 µg/l**	OECD 201

Environmental hazard data from the EU RAR		
Compartment/Species	Results	Test
SEWAGE TREATMENT PLANT		
MICRO-ORGANISMS		
Activated sludge	EC_{50} 15 mg/l	Respiration inhibition OECD 209
SEDIMENT COMPARTMENT		
INVERTEBRATES		
Hyalella Azteca (Amphipod)	LOEC >1000 mg/kg dwt of sediment NOEC 1000 mg/kg dwt of sediment.	Sediment toxicity test 28-day exposure period under flow-through conditions.
Lumbriculus variegatus (Worm)	LOEC = 28.7 mg/kg dwt NOEC = 3.1 mg/kg dwt Normalized: NOEC = 8.61 mg/kg dwt	28d- sediment bioassay
Chironomus riparius (insect - midge)	LOEC = 159 mg/kg dwt NOEC = 13.6 mg/kg dwt Normalized: NOEC = 37.8 mg/kg dwt	28d- sediment bioassay Egg production of F1 generation
TERRESTRIAL COMPARTMENT		
Soil microorganisms	NOEC > 750 mg/kg dry Soil	Nitrogen transformation test OECD 216
PLANTS		
Plants: corn (*Zea mays*), cucumber (*Cucumis sativa*), onion (*Allium cepa*), ryegrass, (*Lolium perenne*), soybean (*Glycine max*), and tomato (*Lycopersicon esculentum)*	NOEC >5000 mg/kg dry Soil	Seedling emergence, survival, height 21 days OECD 308
INVERTEBRATES		

Environmental hazard data from the EU RAR		
Compartment/Species	Results	Test
Eisenia fetida (Earthworm)	NOEC 128 mg/kg dry soil Normalized: NOEC 59 mg/kg dry soil (EC_{50} 771 mg/kg dry soil)	Survival and reproduction, 56 days OECD 207 and OPPTS 850.6200

Of key importance to this assessment are the properties that define HBCDD as a substance that is persistent, bioaccumulative and toxic (PBT) for the environment. The assessment of the properties of HBCDD according to persistence, bioaccumulation and toxicity (PBT) criteria as set out in Annex XIII of the REACH regulation was done by the Swedish Competent Authority and it was concluded to meet the criteria for PBT (ECHA 2008[105]), based on the following:

- **Persistence** - two degradation simulation studies in soil. In the first one the half-life for the γ-HBCDD diastereomer was 119 days when recalculated to 12°C. In the other study no transformation was observed after 112 days of incubation.

- **Bioaccumulation** - HBCDD meets the vB (very bioaccumulative) criterion based on reliable experimental BCFs from two flow-through bioconcentration tests with fish. A BCF of 18,100 was chosen as a representative value in the EU risk assessment (European Commission, 2007). Furthermore, a large set of measured data in biota in the field indicated, that HBCDD is biomagnified in the environment.

- **Toxicity** - HBCDD fulfils the T criterion. A 21d-NOEC of 3.1 μg l-1 has been derived for the freshwater invertebrate species *Daphnia magna* in a flow-through test. It was noted, that ecotoxicity testing of HBCDD is highly complicated due to its very low water solubility. As noted in section 1.2.3 of this report, although HBCDD was identified at an SVHC on the basis of PBT, with the T criterion based on the ecotoxicity, the reproductive toxicity classification is relevant to the possible impacts in the environment and also to humans.

ECHA 2008, also reports that HBCDD has a high potential for long-range environmental transport. Its half-life in the atmosphere is > 2 days and it has been found in remote areas in abiotic samples (air, deposition, sediment) and biota (polar bears, bird eggs, seals) in the majority of samples of a number of years. Additionally, a study comparing long-range transport potential of “existing” POPs and HBCDD with tuna fish samples, found HBCDD to have a very high potential for long-range environmental transport.

[105] (ECHA 2008) Member State Committee Support Document For Identification Of Hexabromocyclododecane And All Major Diastereoisomers Identified As A Substance Of Very High Concern Adopted on 8 October 2008

As mentioned in section 1.2.3 of this report the substance is also classified for human health as suspected of damaging fertility or the unborn child that it may cause harm to breast-fed children. Although directed at protection of humans, the basis for these effects may also need to be taken into consideration in the full SEA study as these effects could be relevant to impacts on wildlife.

Designation as a PBT indicates that there is a concern for HBCDD because it can remain for a long time in the environment and accumulate in the food chain. HBCDD therefore has the potential to exert toxic effects far from where it is released. This concern is taken up by the current evaluation of HBCDD for adding to the list of substances that are persistent organic pollutants (POPs) for control under the UNEP Stockholm Convention. The concern for secondary poisoning means it cannot be disregarded that concentrations in the environment may be reached though accumulation in the food chain that will cause harm to wildlife.

Although it may be shown by the current CSR for registration under REACH that the predicted environmental concentrations (PECs) are lower that the PNECs, the designation as a PBT and possible POP (persistent organic pollutant), means that any releases of the substance may stay and accumulate in the environment. HBCDD environmental fate pattern is much like other POPs because due to its physicochemical properties releases to the atmosphere may be transported over long distances, but it can then be deposited again to earth (e.g. soil) where is can accumulate and be taken up by living organisms. Further information on environmental fate and transport will be brought into the full study especially for the consideration of environmental impacts.

D.2 Environmental Exposure

Regional environmental exposure from the releases of all exposure scenarios (i.e. formulation of EPS, manufacture of EPS articles and service life of EPS articles) is shown below:

The total regional releases based on the exposure scenarios (ES) (as described in Sections 9.1 - 9.3 of the CSR) are as follows:

Waste water: 0.022 tonnes/year

Surface water: 0.0024 tonnes/year

Air: 0.064 tonnes/year

Soil: 0 kg/year

The zero release to soil indicates that there is no direct release to soil from the exposure scenarios assessed. Exposure to soil from spreading of sludge is considered as a worst case for the relevant exposure scenarios assessed.

A summary of predicted regional exposure concentrations (Regional PEC) is set out below:

Table D.5 Regional predicted environmental concentrations for HBCDD from EPS use

Protection target	Regional PEC	Units
Fresh Water	8.7E-08	mg/l
Marine Water	8.5E-09	mg/l
Air	2.7E-09	mg/m^3
Agricultural soil	1.9E-06	mg/kgwwt
Fresh Water (sediment)	6.2E-05	mg/kgwwt
Marine Water (sediment)	3.0E-06	mg/kgwwt

The regional exposure for man via the environment in terms of the regional total estimated daily intake for humans is shown below.

Table D.6 Estimated daily dose and concentration in food from HBCDD from EPS use

Type of food	Estimated daily dose from regional exposure (mg/kg/day)	Concentration in food from regional exposure
Drinking water	5.7E-10	2.0E-08 mg/l
Fish	2.4E-06	1.4E-03 mg/kg
Leaf crops	2.6E-07	1.5E-05 mg/kg
Root crops	4.0E-08	7.3E-06 mg/kg
Meat	4.4E-08	1.0E-05 mg/kg
Milk	2.6E-08	3.3E-06 mg/kg
Air		

A detailed assessment of environmental exposure is set out in the CSR at sections 9 and 10 and also in the environmental modelling report at Appendix F and summarised in Section 5.3 of this report.

APPENDIX E: EPS MARKET QUESTIONNAIRE

HBCDD Questionnaire relating to FR EPS final products

Date: 10/01/2013

Background to this questionnaire

Following the meeting on 19th December 2012 a series of slides containing questions were proposed by PFA/eftec which relates to the Flame Retardant (FR) EPS final (end) products. These questions were originally intended for companies' further downstream (EPS converters). As a result of discussions at the meeting, it was decided that consortium members were better placed to answer these questions and/or via their own contact with their customers.

Therefore PFA/eftec has developed this questionnaire which has also been reviewed by a consortium member. As agreed in the December meeting, members are requested to provide written responses to REACH Centrum (Leo Appelman - lap@reachcentrum.eu) by the 15th February 2013. Depending on the quality of responses received, this should hopefully be the last questionnaire requiring data from members. Note as discussed all questionnaires sent to members to date will need to be completed for any new members joining the consortium.

A written summary can then be prepared by PFA/eftec which can then be distributed downstream for their comments rather than a questionnaire requesting information. It is thought this would be a better means of getting feedback along the supply chain.

Section 1: The FR EPS building applications market

1. What are the main types of building application products made using EPS FR pellets at an EU level? (E.g. ETICS, Flat roof insulation, pitch roof insulation, EPS drainage boards, etc.)

2. Recognising that demand for specific types of buildings related products will vary by region, please provide a description of some of the variations in FR EPS sales by region/Member state and the reasons for this variation?

3. What are the average EU prices (€/t) for these building application products? (E.g. €/t for ETICS, Flat roof insulation, pitch roof insulation, EPS drainage boards, etc.)

4. Do EPS converters (i.e. those who buy EPS pellets to make beads and boards) make any products that do not use FR EPS e.g. non FR EPS and non EPS related products? If so, please provide a list of these products and what proportion of production these account for (e.g. 20% of production is for non-FR EPS, 20% for making product B and 60% for making FR EPS products).

5. How do EPS converters expect demand for FR EPS to change in the future (e.g. 2014-2020)? I.e. increase, decrease or no change.

[*Note we already have responses to this question from members, so this should strictly be responses from any feedback you have from your customers*].

6. On average how much FR EPS final products are made each year by your customers (i.e. by EPS converters)? Where possible, provide a breakdown by type of product (tonnes per year)

7. If it is not possible to answer Q6, please estimate the average ratio of FR EPS relative to the final FR EPS product based on the main types of EPS final products (see Q1)? (e.g. 0.01 tonne of FR EPS is typically used to make 1 tonne of ETIC)

8. How are EPS converters likely to respond if authorisation for continued use of HBCDD in EPS is refused, under the following scenarios:

   a. No EPS pellets is available from the EU (FR and non-FR)

   b. Only non-FR EPS is available in the short term in the EU

   c. Some limited supply of FR EPS pellets are available using a polymeric FR (+ full EU supply of non-FR EPS)

   d. EU supply of EPS pellets are available using another alternative FR?

[*Note we already have responses to this question from members, so this should strictly be responses from any feedback you have from your customers*]

9. Were your customers to receive sufficient supply of FR EPS pellets using the polymeric FR alternative do they envisage any initial barriers (technical/regulatory/marketing/sales) to its use in all building applications?

[*Note we already have responses to this question from members, so this should strictly be responses from any feedback you have from your customers*]

10. If there are any barriers, what actions do EPS converters need to take and how long do they expect that will take? (E.g. regulatory approval, establishing a market, etc.)

11. To what extent can FR EPS products be replaced by mineral wool:

    a. Are they technically suitable for all FR EPS building applications? (if not, which specific building applications and why are they not suitable)

    b. Are there any financial barriers we should be aware of with mineral wool? (e.g. longevity, purchase price, thermal value)

12. To what extent can FR EPS products be replaced by PIR/PUR:

    a. Are they technically suitable for all FR EPS building applications? (if not, which specific building applications and why are they not suitable

    b. Are there any financial barriers we should be aware of with PIR/PUR? (e.g. longevity, purchase price, thermal value)

APPENDIX F: HBCDD: MODELLING OF CONCENTRATIONS IN SEDIMENT AND SOIL OVER TIME

This Appendix is available as a separate attachment

APPENDIX G: DEMAND AND SUPPLY OF PFR – SENSITIVITY ANALYSIS

In the SEA report, Table 4.1 estimates that the economic cost to FR EPS pellet manufacturers from lost production would be €1,175million (PV 2015-2019) and Table 5.1 estimated the total loss at €113million (PV 2015-2019) for FR EPS convertors. The total loss of ~€1.29bilion (over 4.5 years) results from a shortage in supply of the pFR relative to forecasted demand. The calculations of economic costs were based on several variables: some of which are known with certainty, while others are not (but based on expert judgement).

The sensitivity analysis results shown in Table G.1 below seek to clarify the impact of changes in key variables used. A total of eight scenarios were undertaken, indicating the variables changed (relative to the existing value), with some narrative description of the likelihood of these variables occurring in practice.

A change in the assumption/variable could result in a positive change (% terms in the last column), which means that the economic costs could be higher than the current €1.29billion estimate; or a negative change meaning the economic costs would be lower than the current estimate.

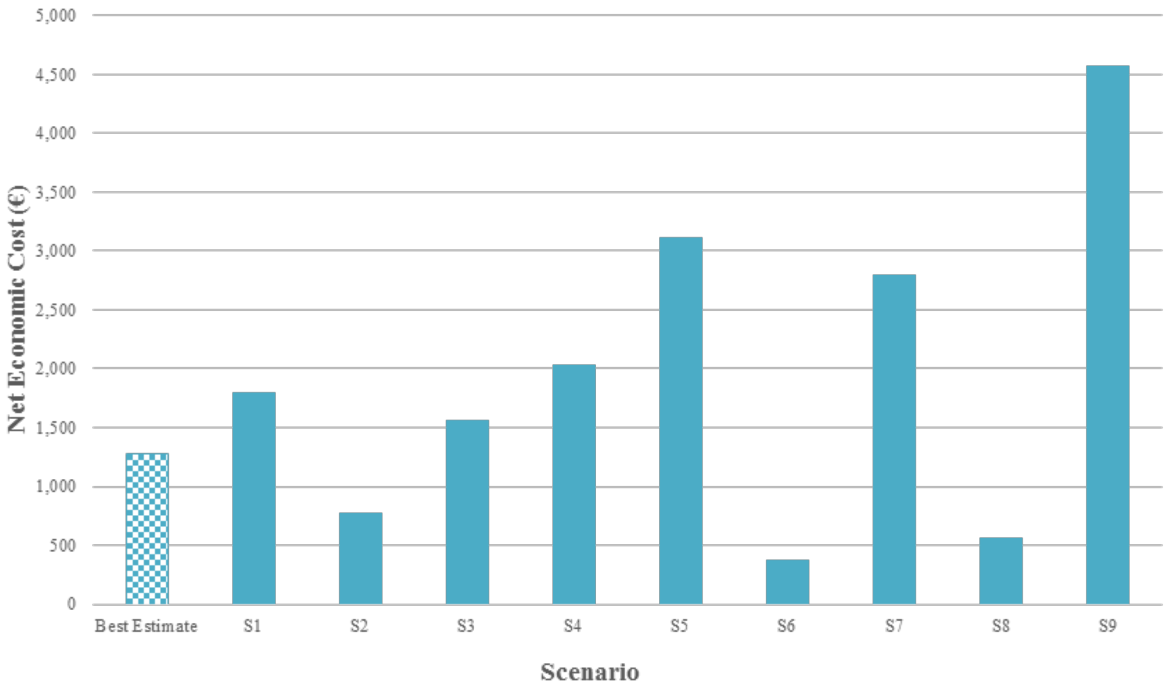
Table G.1 Results of sensitivity analysis

Scenario	Original variable being changed	New value/assumption	Rational	New economic cost value (PV 2015-2019)	% change in PV relative to €1.29bn
1	50% of Chinese demand for HBCDD switches to pFR in 2019 (no use of pFR before then)	100% switch by 2018-19	It is possible if China adopts the UNEPs ban on use of HBCDD post 2019	1,804	+40%
2	50% of Chinese demand for HBCDD switches to pFR in 2019 (no use of pFR before then)	Continued use of HBCDD over whole time (0% use of pFR)	It is possible that China may opt out of the UNEP process and therefore continue to use HBCDD for FR EPS (although FR EPS will only be able to be used in those countries not covered by UNEPs decision e.g. domestic use).	772	-40%
3	50% of America (North and South) switch to pFR over period 2015-2019	100% switch	50% of supply is known to have already (or due to) switch to pFR. It is possible that all companies switch to pFR	1,567	+22%
4	No growth in FR EPS or XPS over the period 2015-2019 outside of EU	3% growth	Possible those other non-EU countries will demand more EPS and XPS to also improve building efficiencies (e.g. CO2 targets, energy security and climate resilience).	2,036	+58%
5	No growth in FR EPS or XPS over the period 2015-2019 outside of EU	7% growth	Possible those other non-EU countries will demand more EPS and XPS to also improve building efficiencies (e.g. CO2 targets, energy security and climate resilience).	3,110	+141%
6	No growth in EU in 2013 and 2014. EU demand for EPS grows from 3% in 2015 rising to 7% in 2018. No growth in EU in 2013 and 2014. EU demand for XPS grows from 3% in 2015 rising to 6% in 2018.	0% growth in EPS and XPS over period 2015-2019	Considered unlikely given demand for greater energy efficiency from homes by 2020 and beyond. Efficiency in energy would have to meet through other measures to meet targets which are unlikely to be as cost effective	383	-70%
7	There are potentially additional alternatives to HBCDD for XPS other than pFR. It is assumed that up to 50% can be replaced by such alternatives; 15% in 2017 rising to 47.50% in 2019.	Preference for pFR by XPS leading to no switching from pFR	Possible as the pFR was specifically designed for XPS and it is thought at least of the EU that most major companies will switch to the pFR	2,797	+117%

Scenario	Original variable being changed	New value/assumption	Rational	New economic cost value (PV 2015-2019)	% change in PV relative to €1.29bn
8	Nameplate supply capacity of 33k over the period 2015-2019 with a 95% product utilisation rate.	All parties increase capacity by further 2kt at 95% utilisation rate with a 18 month lead time from when their existing plants are operational	Chemutra have indicated that they could increase capacity further although no specific amount is quoted. It is assumed in this scenario that additional lines could be added in up to 2kt for all three companies. Chemutra in 2017, ICL in 2018 and Albemarle in 2019.	570	-56%
9	All pFR suppliers are assumed to come online as scheduled.	The Albermarle site does not come online until post-UNEP, in 2019.	It is understood that no construction work has begun for the production site so it is possible that it may not come online by the sunset date.	4,568	+255%

Figure G.1 illustrates the economic cost under 9 scenarios to EPS pellet producers and convertors. It shows that all scenarios result in a net cost and how they compare relative to the best estimate (€1.29billion).

Figure G.1 Economic cost under the 9 sensitivity analysis scenarios



The sensitivity analysis does help to highlight there is significant business uncertainty around sufficient supply of the pFR relative to demand. The results indicate that these changes to key variables have a significant effect on the headline number, with the net economic cost value rising as much as 255% or falling by 70%, relative to the current €1.29bn estimate. However in all cases there is a net cost due to insufficient supply relative to demand.

It is acknowledged that this type of uncertainty analysis does not account for simultaneous variations in multiple factors. For example, if in addition to no growth in EPS and XPS (over 2015-2019), all pFR supplies increased their nameplate capacity by a further 2kt each, then the economic cost value will be even lower than €379 million. Similarly, if there was both 7% growth in FR EPS or XPS outside the EU and the preference for using pFR (rather than other *possible* alternatives for XPS), then the economic cost value could be even higher than €2.99 billion estimate. However by undertaking such hypothetical scenario analysis it is clear that it would only serve to make the economic cost range even larger, thereby increasing uncertainty rather than decreasing it.