Study on the Use of the Flame Retardant HBCDD in Building Insulation Materials in Ireland

As Restricted Under EU Persistent Organic Pollutants (POPs) Regulation 2019/1021

Client: Environmental Protection Agency
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Glossary

BAT	Best Available Techniques
BER	Building Energy Rating
CFC	Chlorofluorocarbon
CIF	Construction Industry Federation
CSO	Central Statistics Office
C&D	Construction & demolition
DLRCC	Dún Laoghaire-Rathdown County Council
EPA	Environmental Protection Agency
EPS	Expanded polystyrene
EC	European Commission
ECHA	European Chemicals Agency
EU	European Union
EUMEPS	Association for European Manufacturers of Expanded Polystyrene (EPS)
EXIBA	Extruded Polystyrene (XPS) Insulation Board Association
HBCDD	Hexabromocyclododecane
HCFC	Hydrochlorofluorocarbon
HIPS	High impact polystyrene
IADC	Irish Association of Demolition Contractors
LCCC	Limerick City & County Council
LOUS	List of Undesirable Substances (Denmark)
MSDS	Material Safety Data Sheet
m^2	square metres
m^3	cubic metres
NIAI	National Insulation Association of Ireland
OJEU	Official Journal of the European Union
OPW	Office of Public Works
PAH	Polycyclic aromatic hydrocarbon
PCB	Polychlorinated biphenyl
PIR	Polyisocyanurate
ppm	Parts per million
REACH	Registration, Evaluation, Authorisation, and Restriction of Chemicals
SCCP	Short-chain chlorinated paraffins
SDCC	South Dublin County Council
SDS	Safety Data Sheet
SVHC	Substance of Very High Concern

UK	United Kingdom
USA	United States of America
UNEP	United Nations Environment Programme
XPS	Extruded polystyrene
XRF	X-ray fluorescence

Executive Summary

This report has been prepared by Sweco to document the findings of a study, completed on behalf of the Environmental Protection Agency (EPA), to investigate the historical use of hexabromocyclododecane (HBCDD) in Expanded Polystyrene (EPS) and Extruded Polystyrene (XPS) foams in building materials within the Republic of Ireland. This study considers the potential risks associated with HBCDD uses within an Irish context and the implications, both medium and long term, for its appropriate management. In the coming years and decades, future building renovation and demolition works are likely to result in an increase in the generation of insulation waste materials containing HBCDD.

Background

HBCDD is a chemical first produced in the 1960s which became one of the most commonly used brominated flame retardants in building insulation materials. HBCDD is known to be persistent, bioaccumulative and toxic, posing risks to both human health and particularly the aquatic environment. In the EU, EPS and XPS insulation materials are understood to account for approximately 95% of total HBCDD production volumes.

Within the EU, the prohibition of HBCDD took effect from 2016 by way of the EU POPs Regulation. Annex IV of the EU POPs Regulation established a concentration limit of 1,000 mg/kg for HBCDD in waste streams. An update of the EU Regulation in 2022 will result in the Annex IV concentration limit for HBCDD being lowered to 500 mg/kg, with a subsequent reduction over time to a value not higher than 200 mg/kg. Below the Annex IV limit, HBCDD-containing waste materials can be recycled. Above this limit, such waste materials must be treated in a way the HBCDD content is destroyed or irreversibly transformed, e.g. incinerated.

Study Methodology

Following the development of a project plan, this study first involved the identification of the main, relevant economic operators likely to have manufactured and/or supplied HBCDD-containing EPS and XPS insulation materials within the State during the study period (1990-2016). This timeframe was chosen to reflect the period for use of HBCDD-containing EPS and XPS insulation materials, which is understood to have largely coincided with the thermal efficiency requirements of the Irish Building Regulations (Part L) first introduced in 1990 up to the EU ban on HBCDD in 2016.

An online survey regarding the manufacture and supply of EPS and XPS insulation materials, including questions on the use of HBCDD, was developed and issued to the main, relevant economic operators identified. However, no responses to the issued survey were returned. Further to additional contact by telephone and email, feedback from survey recipients indicated a number of difficulties in completing the survey which are documented in this report.

In the absence of survey data, further consultation was initiated with the National Insulation Association of Ireland (NIAI) to understand, insofar as possible, the sectoral knowledge available regarding the supply of HBCDD-containing EPS and XPS insulation materials in the Republic of Ireland. An alternative methodology was also utilised to estimate the volumes of HBCDD-containing EPS and XPS insulation materials supplied within the State. This alternative methodology was based on likely demand for building insulation materials and focused on the residential building stock, with limitations on similar estimations for the non-residential building stock during the period of investigation (1990-2016).

A review and benchmarking of approaches employed in other EU Member States regarding the removal and management of HBCDD-containing EPS and XPS insulation materials was also carried out. This benchmarking review focused on three Member States, namely the Netherlands, Sweden and Denmark.

Key Findings

The lack of survey data has limited the output of the study as originally envisaged. However, the main findings may be summarised as follows:

Sectoral Knowledge: Consultation with the NIAI has identified that while EPS and XPS products containing HBCDD are known to have been supplied for use in the Irish market (consistent with other markets), no manufacturing of such products is known to have occurred in Ireland during the period of investigation (1990 to 2016). The demand for XPS materials in Ireland for the period of investigation is understood to have been relatively low. However, the introduction of new Building Control Regulations in 1991 resulted in a major increase in demand for EPS insulation materials with an estimated market share of 80-85% of all insulation materials installed in residential buildings. This market share is understood to have remained broadly consistent between 1991 and 2005, reducing to approximately 20-25% up to 2016, owing to a shift in demand

for polyisocyanurate (PIR) based insulation materials. Imports of EPS products are known to have been sourced mainly from Germany and also the Netherlands. HBCDD is known to have been widely used as a fire retardant and it can be reasonably assumed that all EPS insulation materials supplied in Ireland (and other markets) during the period of investigation contain HBCDD.

Estimated Volumes of HBCDD-containing EPS & XPS Insulation Materials Supplied within the State: As noted previously, the volumes of HBCDD-containing EPS and XPS insulation materials supplied within the State were estimated based on likely demand during the period of investigation in the absence of survey data for supply. The alternative methodology employed for estimation of these volumes was considered appropriate for the residential building stock only and the corresponding insulation material quantities for the non-residential building stock remain a knowledge gap.

Between 1991 and 2016, it is estimated that the annual average volumes of HBCDD-containing EPS insulation products required for use in the new residential building stock varied significantly from a peak of 438,000-474,000 m^3/year (2001-2005) to a low of 22,000-25,000 m^3/year (2011-2016), with an average of 310,500 m^3/year (1991-2016). The corresponding annual average volumes of HBCDD-containing XPS insulation products varied from a peak of 51,000-56,000 m^3/year (2001-2005) to a low of 4,000-5,000 m^3/year (2011-2016), with an average of 40,000 m^3/year (1991-2016).

Estimated Volumes of HBCDD-containing EPS & XPS Insulation Wastes Arising Annually: The potential volumes of HBCDD-containing EPS and XPS insulation waste arising over the next 20 years are likely to be subject to significant variation year-to-year. Three future scenarios have therefore been considered assuming a range in the percentage of the residential building stock which will be subject to renovation and/or demolition annually and the likely volumes of existing insulation requiring removal. In the case of HBCDD-containing EPS insulation waste, the annual volume arising could range from 12,500 m^3/year (low volume scenario) up to 238,500 m^3/year (high volume scenario). The corresponding volumes for HBCDD-containing XPS waste arising are estimated as 1,500 m^3/year (low volume scenario) and 28,500 m^3/year (high volume scenario).

The remediation of buildings impacted by defective building materials including pyrite and mica, is likely to be a significant source of HBCDD-containing insulation waste in future with a review of the likely waste quantities from this source further detailed within the report.

Benchmarking: In the **Netherlands**, waste regulations include specific provision for HBCDD-containing waste by way of a sector plan for waste EPS material which mandates treatment of such waste in accordance with the EU POPs Regulation (typically incineration). It is projected that approximately 1,130 kilotonnes of HBCDD-containing EPS and XPS waste will be generated in the Netherlands between 2016 and 2075, with decreasing quantities after this time to 2090. A new waste treatment process *'PolyStyreneLoop'* remains in the early stages of development. This involves dissolution and separation of HBCDD content from EPS, with bromine recovery and recycling of residual plastic. In **Sweden**, national regulation requires that waste containing POPs (including HBCDD) above 'EU Annex IV' concentration limits be treated as hazardous with requirements for source segregation and incineration. For construction and demolition (C&D) waste, a control plan must identify and set out how hazardous waste streams will be managed. Building renovation and demolition projects require a material inventory which in turn informs a project waste management plan. A number of guidelines have been developed which identify insulation materials containing brominated flame retardants as hazardous. In **Denmark**, there is no equivalent regulatory provision specific to HBCDD-containing waste however brominated flame retardants are listed on the Danish EPA's 'List of Unwanted Substances (LOUS)'. The onus remains with the waste producer to classify all waste and municipalities may also determine if a waste stream is to be treated as hazardous. Producers of C&D waste are obliged to segregate hazardous waste streams. Danish guidelines note the requirement for incineration of brominated flame retardants in waste.

Recommendations

A number of recommendations have been included which may help to further understand the supply of HBCDD-containing EPS/XPS insulation in Ireland, inform future waste trends and also guide the management of associated waste streams. These include a review of future building demolition and renovation trends in conjunction with relevant construction sector bodies and authorities; engagement with stakeholders for buildings requiring remediation due to defective building materials; audits of construction and demolition projects; and development of a fact sheet on HBCDD to raise awareness and provide guidance on appropriate construction and demolition waste management.

1. Introduction

1.1 Background

Sweco Ireland Ltd. (Sweco) was commissioned by the Environmental Protection Agency (EPA) to investigate the use of hexabromocyclododecane diastereoisomers (HBCDD) in Expanded Polystyrene (EPS) and Extruded Polystyrene (XPS) foams used in building materials within the Republic of Ireland. EPS and XPS insulation materials are understood to account for approximately 95% of total HBCDD production volumes.

Studies over the past two decades have found HBCDD to be persistent, bioaccumulative and toxic, posing risks to both human health and particularly the aquatic environment. HBCDD was classified as a Persistent Organic Pollutant (POP) by its listing in Annex A of the Stockholm Convention in 2013 and its inclusion in Annex I of the EU POPs Regulation (Regulation (EU) 2019/1021) in March 2016. This resulted in the prohibition on manufacturing, placing on the market and use of HBCDD subject to certain exemptions.

The results of the project are intended to inform the assessment of the potential risks associated with HBCDD use in XPS and EPS insulation within the Irish context and the implications, both medium and long term, for its appropriate management.

1.2 Scope of Work

The main objective of this study is to determine the historic levels of use of HBCDD-containing EPS and XPS foams used in building materials within the Republic of Ireland.

The scope of work included the following tasks:

Task 1 – Project Plan

This Plan outlined the methodologies proposed for completion of the tasks as set out in the EPA Specification of Requirements (EPA ref. SPCP-2018-02-1 Lot #3, Section 2.3). This Plan was issued to the EPA on 8 December 2021.

Task 2 – Identification of main, relevant economic operators likely to have manufactured/supplied HBCDD-containing EPS and XPS insulation for relevant applications

The identification of the main, relevant economic operators likely to have manufactured/supplied HBCDD-containing EPS and XPS insulation is further described in Section 1.7.1. The operators identified are listed in Annex A.

Task 3 – Survey of and engagement with relevant economic operators identified

The survey methodology is described in Section 1.7.2. The intention of the survey was to gather relevant information directly from the main economic operators regarding HBCDD-containing EPS and XPS insulation materials, specifically the volumes of materials supplied over the period under investigation. As described later in the report, significant challenges were encountered in stakeholder engagement with no responses provided to the online survey.

Task 4 – Estimation of total annual volumes of HBCDD-containing EPS and XPS insulation materials supplied within the State over the period under investigation

In the absence of meaningful survey engagement, this estimation considered relevant applications for EPS and XPS materials, using alternative data sources available and consultation with the National Insulation Association of Ireland (NIAI). The methodology for estimation is described in Section 1.7.3.

The volumes estimated are contained within Section 3.1.3 (Key Project Findings).

Task 5 – Estimation of volumes of HBCDD-containing EPS and XPS insulation wastes arising annually over the next 20 years due to its removal and potential implications regarding the management of these wastes

The methodology for estimation of these waste volumes is described in Section 1.7.4.

The waste volumes estimated are contained within Section 3.2 (Key Project Findings).

Task 6 – Review and benchmarking of approaches employed in other Member States regarding the removal and management of HBCDD-containing EPS and XPS insulation materials

Based on known progress in regulatory frameworks and certain technological advances in the treatment of HBCDD, a review and benchmarking of approaches employed in three other EU Member States, namely Sweden, Denmark and the Netherlands was carried out. This review is documented in Section 2.

Task 7 – Generation of Project Report and associated outputs, including knowledge gaps identified and any recommendations for future related work.

This report comprises the output of Task 7.

1.3 Hexabromocyclododecane

Hexabromocyclododecane (HBCDD) (molecular structure shown in Figure 1) is a bromoalkene, a bromohydrocarbon and a brominated flame retardant[1]. HBCDD was first produced in the 1960s and since then, became one of the most commonly used brominated flame retardants in EPS and XPS, as well as uses in High Impact Polystyrene (HIPS) and in polymer dispersion for textiles. End of life disposal of materials containing HBCDD will represent a long-term source of emissions into the environment[4]. HBCDD is a hydrophobic molecule (has low water solubility).

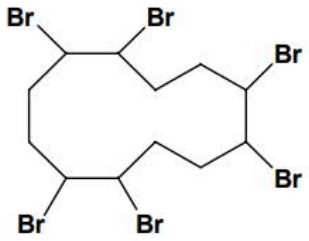


Figure 1: The molecular structure of HBCDD ($C_{12}H_{18}Br_6$)

1.4 Environmental and Human Health Risks

The key risks for the environment and human health associated with HBCDD are detailed in the Report of the Persistent Organic Pollutants Review Committee of United Nations Environment Programme (UNEP) on the work of its sixth meeting in 2010[2]. In the European Union (EU), HBCDD has been identified as a substance of 'very high concern' based on its persistency, bioaccumulation and toxicity. In the US, an initial screening assessment of HBCDD concluded that there is a high concern for aquatic organisms from environmental releases, based on the bioaccumulation potential of HBCDD, the high acute toxicity for aquatic plants and chronic toxicity for aquatic invertebrates, and also the potential for exposure and presence in remote regions[3].

The EU risk assessment of HBCDD completed in 2008[4] provides a comprehensive assessment of toxic effects and risks of HBCDD exposure to human health and welfare. This assessment concluded that HBCDD may cause reproductive toxicity and long-term toxicity, whereas there is no concern for acute toxicity, irritation, sensitisation, mutagenicity and carcinogenicity. It moreover states that HBCDD poses no risk to adult consumers or to workers when standard industrial hygiene measures are applied (current EU practice). These conclusions are founded on an extensive list of toxicity studies and on a comprehensive selection of

[1] PubChem https://pubchem.ncbi.nlm.nih.gov/compound/1_2_5_6_9_10-Hexabromocyclododecane

[2] Report of the Persistent Organic Pollutants Review Committee on the work of its sixth meeting, Addendum 2 – Risk profile on hexabromocyclododecane, UNEP, October 2010

[3] US EPA (US Environmental Protection Agency). Initial Risk-Based Prioritization of High Production Volume Chemicals. Chemical/Category: Hexabromocyclododecane (HBCD). Risk-Based Prioritization Document 3/18/2008

[4] Risk Assessment Report – Hexabromocycledodecane. Final report (R044_0805_env_hh_final_ECB.doc), European Chemicals Bureau, May 2008

exposure and risk assessments that consider not only workers and adult consumers, but also indirect exposure of humans via the environment.

1.5 Regulation of HBCDD

1.5.1 Global Regulation - Stockholm Convention

The Stockholm Convention on POPs was adopted in May 2001. This global treaty requires its Parties to take measures to eliminate or reduce the release of POPs into the environment.

The POPs and resulting actions for the Parties are categorised under three Annexes:

- Annex A: Parties required to take measures to eliminate production and use of the listed chemicals. The specific exemptions for use or production as listed only apply to Parties that register for them.
- Annex B: Parties required to take measures to restrict the production and use of the listed chemicals, unless for acceptable purposes/ specific exemptions detailed in the Annex; and
- Annex C: Parties required to take measures to reduce the unintentional release of chemicals, with the goal of their continuous minimisation and where feasible, ultimate elimination.

HBCDD was added to Annex A of the Stockholm Convention in 2013.

1.5.2 European Regulation

HBCDD is included among the brominated flame retardants group in the List of Substances for Priority Action of The Convention for the Protection of the Marine Environment of the North-East Atlantic (the OSPAR Convention).

In 2008, HBCDD was identified by the European Chemicals Agency (ECHA) as a Substance of Very High Concern (SVHC) within the framework of the REACH Regulation[5]. In 2011, HBCDD was included in Annex XIV to the REACH Regulation and made subject to the authorisation procedure under REACH (with a sunset date in 2015), regulating its use and placement on the market. HBCDD is classed under CLP Regulation[6] (EC) 1272/2008 (as amended) as reprotoxic (Cat. 2, H361; Lact., H362) and hazardous to the aquatic environment (acute and chronic, Cat. 1, H400 and H410).

In May 2010, HBCDD was also added to the List of Substance for Priority Action of the Convention on the Protection of the Marine Environment of the Baltic Sea Area (also known as the 'Helsinki Convention').

EU POPs Regulation

The Stockholm Convention was first given effect in the EU by Regulation (EC) No. 850/2004, which was subject to several amendments subsequently. This Regulation has since been repealed and replaced by the current EU POPs Regulation (Regulation (EU) 2019/1021) which controls manufacture, placing on the market and use of POPs in both mixtures and articles. The Regulation also sets out strict requirements for the management of wastes containing POPs over specified concentrations.

Annex I of the POPs Regulation lists those substances subject to prohibition on manufacturing, placing on the market and use (and incorporates the substances listed in Annex A to the Stockholm Convention). Annex IV sets concentration limits for certain POPs in waste, which define whether such waste can be recycled or disposed of or managed by a method listed in Annex V to ensure that the POP content of the waste is

[5] Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC

[6] Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 on classification, labelling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EEC, and amending Regulation (EC) No 1907/2006

destroyed or transformed. It also sets maximum concentration limits for POPs, below which the treatment of the contaminated waste can be exceptionally allowed, according to Article 7(4)(b) of the Regulation.

In March 2016, HBCDD was included in Annexes I[7], IV and V[8] of the EU POPs Regulation. Initially the Annex IV concentration limit for HBCDD was set at 1,000 mg/kg subject to review by the European Commission.

In October 2022, the Council of the EU formally adopted a Regulation[9] which lowers the Annex IV concentration limit for HBCDD to 500 mg/kg, with a subsequent reduction to a value not higher than 200 mg/kg, five years after the date of entry into force of the Regulation (subject to review by the EU Commission). The adoption of the Regulation follows a provisional political agreement reached with the European Parliament on 21 June 2022. The Regulation will enter into force on the twentieth day following that of its publication in the Official Journal of the European Union (OJEU). This Regulation shall apply as of six months after publication in the OJEU.

1.5.3 Irish Regulation

The Stockholm Convention formally entered into force in Ireland in 2010, further to the enactment of the Persistent Organic Pollutants Regulations 2010, S.I. 235 of 2010. For the purposes of compliance with the latest EU POPs Regulation, the aforementioned Irish Regulations of 2010 were revoked and replaced by the European Union (Persistent Organic Pollutants) Regulations 2020, S.I. 146 of 2020.

Under these Irish Regulations, the EPA is the competent authority responsible for the administrative tasks and enforcement required by the EU POPs Regulation.

1.6 Use of HBCDD in EPS/XPS Insulation

HBCDD has been on the world market since the late 1960s. As noted in Section 1.5, parties to the Stockholm Convention have been obliged to take measures to prevent its manufacture and use over the course of the past decade. Under the terms of the Convention, certain time-limited exemptions for the production and use of HBCDD were secured by several countries as well as the EU with the last of these specific exemptions (China) having expired in December 2021[10]. The ban on production and use of HBCDD has since resulted in the introduction of alternative replacement products.

HBCDD was produced mainly in China, the EU, Japan and the United States of America. The total production of HBCDD was estimated at around 31,000 tonnes in 2011, of which about 13,000 tonnes were produced in EU countries and in the United States, and 18,000 tonnes in China[11].

HBCDD was first introduced commercially as a flame retardant in the 1980s. The main use of HBCDD has been attributed to reducing the flammability of EPS and XPS foams and textiles. It is estimated that over 90% of HBCDD produced has been used as a flame retardant in EPS and XPS foams for insulation materials in industrial and residential buildings in the construction sector. An EU publication[12] estimates that 99.9 per cent of the produced/imported volume of HBCDD in the EU ended up in polystyrene (XPS, EPS) used in the construction and building sector.

The concentrations at which HBCDD is used, depend on the polymer it is used with and on the fire safety requirements. Concentrations will vary from country-to-country depending on differing regulatory standards and requirements. Typical concentrations of HBCDD in different materials are shown in Table 1.

[7] Regulation (EU) 2016/293

[8] Regulation (EU) 2016/460

[9] https://www.consilium.europa.eu/en/press/press-releases/2022/10/24/council-formally-adopts-further-restrictions-to-forever-chemicals-in-waste/

[10] Register of Specific Exemptions – HBCD (http://chm.pops.int/Implementation/Exemptions/SpecificExemptions/HexabromocyclododecaneRoSE/tabid/5034/Default.aspx)

[11] Technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with hexabromocyclododecane, UNEP, 2018

[12] Risk Assessment Report – Hexabromocycledodecane. Final report (R044_0805_env_hh_final_ECB.doc), European Chemicals Bureau, May 2008

Table 1: Typical concentrations of HBCDD in different materials

Building insulation materials	HBCDD content (mg/kg)
Expanded polystyrene (EPS)	5,000-10,000[13]
Extruded polystyrene (XPS)	8,000-25,000[14]

From approximately 2025 onwards, it is expected that the volumes of waste EPS and XPS insulation materials containing HBCDD will increase significantly as older buildings (between 30-50 years) are refurbished, renovated or demolished for new development.

1.7 Methodology

1.7.1 Identification of Main, Relevant Economic Operators

In order to identify the main, relevant economic operators i.e. the relevant manufacturers/suppliers of EPS and XPS in the Republic of Ireland (Task 2), the national and European associations representing these operators were first investigated. The represented manufacturers/supplier companies were included on a preliminary target list for engagement.

Two key stakeholder representative organisations at European level were identified for manufacturers and suppliers within Ireland, namely:

1. EUMEPS - the Association for European Manufacturers of Expanded Polystyrene (EPS)
2. EXIBA – the Extruded Polystyrene (XPS) Insulation Board Association.

EPS Manufacturers & Suppliers

EUMEPS members include 22 National Associations of Expanded Polystyrene (EPS) in Europe, representing EPS converters, raw material suppliers, additive suppliers, EPS recyclers and machinery provider companies. In addition to these institutional members, EUMEPS is engaged with private companies related to the EPS industry. EUMEPS membership comprises 1,000 companies, most of them small and medium sized companies (SMEs).

The National Insulation Association of Ireland (NIAI**)** is a member of EUMEPS, representing the insulation industry in Ireland. NIAI members include manufacturers and installers of various insulation solutions.

A preliminary target list of EPS manufacturers and suppliers was identified based on the known membership list of both NIAI and EUMEPS. While the presence and activity of NIAI members in Ireland is well established, an initial screening of the EUMEPS member list was carried out by means of internet searches to check for the presence of any additional manufacturers/suppliers (outside of NIAI membership) with a presence in Ireland to merit inclusion on the final target list.

Preliminary consultation with the NIAI was carried out by email and telephone to inform the representative body of the study scope and confirm the extent of the association's representation for the sector.

XPS Manufacturers & Suppliers

EXIBA represents the producers of XPS foam and the majority of the production capacity of XPS foams within Europe. Similar to the screening of the EUMEPS member list, a review of the EXIBA member list was carried out by means of internet searches to check for the presence of manufacturers/suppliers with a presence in Ireland for inclusion on the final list of stakeholders for consultation. A number of main agents for EXIBA members were also identified with a presence in Ireland. The NIAI was also consulted on the supply of XPS to Ireland.

[13] Submissions by Canada and PlasticsEurope/Exiba to the Stockholm Convention, 2011 (UNEP/POPS/POPRC.7/19/Add.1).

[14] BFRIP 2005, XPSA and CPIA, PlasticsEurope/Exiba submissions to the Stockholm Convention, 2011 (UNEP/POPS/POPRC.7/19/Add.1).

Target List

The target list of relevant operators for manufacture/supply of EPS and XPS insulation in Ireland was finalised further to review with the EPA and initial feedback from the NIAI.

1.7.2 Project Survey & Engagement

For the purposes of Task 3, a survey was created using ArcGIS for distribution among the main, relevant economic operators identified). A draft version of the survey was prepared in MS Excel format and issued to the EPA on 10 December 2021 for agreement.

Following agreement, the survey was finalised in the ArcGIS platform. A copy of the final survey (PDF format) is included in Appendix 3.

The introduction to the survey included a brief 'how to use' summary to advise recipients on the use of the online survey format, background to the survey and a GDPR statement documenting the data processing details associated with the survey, rights in relation to personal data and links to the EPA's Privacy Policy and the email address for the EPA's Data Protection Officer.

The survey included the following main query fields:

a) Relevant operator contact(s) details
b) Contact name
c) Contact number
d) Contact e-mail address
e) Nature of business (product manufacturer, supplier/agent, other)
f) Manufacturer/supplier of EPS insulation in Ireland during 1990-2016 (Yes/No)
g) Manufacturer/supplier of XPS insulation in Ireland during 1990-2016 (Yes/No).

At this point in the survey, where a respondent identified that the 'operator' was not engaged in the manufacture or supply of EPS / XPS insulation in Ireland during the period of investigation, the survey directed the user to the final submission page. Where the respondent indicated the operator was engaged in a relevant activity, the survey proceeded to the following additional query fields:

h) Years engaged in relevant activity (to be selected from 'manufacture', 'supply', 'other' for EPS and XPS respectively)
i) Relevant brand / product names
j) Tick box (Yes / No / Unsure) or equivalent field to indicate whether product entry/entries previously contained HBCDD
k) Survey field/facility to upload any available supporting information (e.g. insulation specification documents, SDS if relevant etc.).

At this point in the survey, where a respondent indicated that identified products did not contain HBCDD, the survey directed the user to the final submission page. Where the respondent indicated that products manufactured/supplied previously contained HBCDD (or were unsure), the survey proceeded to the following additional query fields:

l) Number of years engaged in the manufacture of the product
m) Number of years engaged in the supply of the product
n) Year when use of HBCDD in this product ceased (or final year of product manufacture if product discontinued)
o) Field for upload of Material Safety Data Sheet (MSDS or SDS) or alternative supporting information relevant to product composition including HBCDD content
p) Average annual volumes of HBCDD-containing EPS insulation manufactured in or supplied to Ireland
q) Annual average volumes of HBCDD-containing XPS insulation manufactured in or supplied to Ireland
r) Text field to record any significant variation that may have occurred in production/supply volumes during the period 1990-2016
s) Field (marked optional) to indicate % HBCDD content for affected products with secondary field to specify alternative units if % content unknown

t) Multiple choice fields to indicate % of business (by relevant product) according to typical end uses/sectors. Survey recipients requested to indicate % for residential, commercial and industrial sectors
u) Comments (free field) for additional information known to operator related to the use of HBCDD in EPS or XPS insulation products / manufacture and supply of such products.

Survey Issue

A survey invitation email was issued to the agreed distribution list on 4 February 2022, including a hyperlink to the online survey form. The survey issue was accompanied by a covering e-mail summarising the project background / survey objective and requesting survey completion by 25 February 2022. The email invite also included an introductory letter issued by the EPA to further encourage response.

All emails were issued using the project specific email address HBCDD@sweco.ie. The covering email advised survey recipients of the use of this contact email address also for any queries in relation to the survey.

A reminder email was sent to the survey recipients one week prior to the submission deadline.

As no responses were received to the survey issue, Sweco completed a series of follow-up telephone calls with the relevant economic operators (survey recipients) to request survey completion and/or a brief telephone interview to discuss the survey more generally and if any relevant information may be available in relation to the manufacture or supply of HBCDD-containing EPS/XPS materials in Ireland.

The feedback received from the limited engagement that was possible with the main economic operators is documented in Section 3 (Key Project Findings) and Section 4 (Knowledge Gaps Observed).

1.7.3 Estimation of Total Annual Volumes of HBCDD-containing EPS and XPS Insulation Materials Supplied Within the State

In the absence of survey engagement, further consultation was initiated with the NIAI by means of telephone calls and online meetings. The aim of this engagement was to identify available sectoral knowledge in relation to the manufacture and supply of EPS/XPS insulation materials supplied within the State and to gain an understanding of the use of HBCDD in such products and typical quantities of EPS/XPS application in buildings. The findings arising from this engagement are reported in Section 3 and any associated knowledge gaps in Section 4. It is noted that the NIAI engaged proactively and openly with Sweco while having constraints in the time and resources available for additional research or direct member engagement.

For the purposes of Task 4 and in the absence of supply side data, an alternative methodology was employed to estimate total annual volumes of HBCDD-containing EPS and XPS insulation materials supplied within the State which focused on the demand during the period of investigation. This involved a review of relevant CSO data including New Dwelling Completions and available housing statistics. For new dwellings constructed during the period of investigation, the area of floor and wall space requiring insulation was estimated by dwelling type as described below.

Residential Building Stock

From the CSO data, the number of dwellings was investigated by period of construction and building type (i.e. detached house, semi-detached house, terrace and apartment). Data on the average floor area by period of construction and type of dwelling was also sourced from the CSO statistics. Combining these datasets provided a typical floor area for each main dwelling type by period of construction e.g. typical floor area (m^2) for apartment / terraced house / semi-detached house etc. during the periods 1994-1999, 2000-2004 etc. This provided a basis for estimation of the total demand in the residential property sector (size by floor area) for floor insulation products during the period of investigation.

For estimating the quantities of wall insulation likely required for new dwellings completed during the period of investigation, a typical floor to ceiling height of 2.4 m was assumed. The typical external wall area for each main dwelling type by period of construction was then calculated based on the typical floor size above. A reduction of 30% in wall area was then applied allowing for external window and door space where insulation materials were not installed and the area of application for wall insulation was reduced. It is noted that this figure will vary significantly based on the design of various dwelling types and to understand such a variation was beyond the scope of this study.

Further to consultation with the NIAI, the estimated thickness of insulation materials installed in floor (60 mm) and wall spaces (50 mm) was applied to calculate the volume of insulation that could be reasonably expected to be installed by dwelling type.

Aggregating the above data, estimates were then calculated for the total likely volume of insulation materials required by dwelling type and period of construction across the housing stock constructed during the period of investigation.

To determine the volume of EPS/XPS insulation products, a percentage factor on the total estimated quantities above was applied based on the estimated market share and demand for these product types.

Non-Residential Building Stock

While statistics are available for the quantity of commercial, industrial and public sector buildings constructed in Ireland, the available data reviewed on the period of construction and size of non-residential buildings is more limited when compared to the corresponding data for housing stock.

Since 2009, the introduction of Building Energy Rating (BER) certificates has resulted in the identification of average floor area for several categories of non-domestic buildings, however this remains limited to those buildings audited since 2009 and will exclude a large number of the building stock which has not been subject to a property transaction (sale or rent) since 2009.

The key constraint in the estimation of insulation product volumes used in the non-residential building stock is the major variation in height, design and layout for such buildings. Estimation of wall height and area for a typical non-residential building will vary greatly. As such the demand for EPS/XPS insulation materials in the non-residential building stock has been identified as a knowledge gap (Section 4).

1.7.4 Estimation of Volumes of HBCDD-containing EPS and XPS Insulation Wastes Arising Annually Over the Next 20 Years Due to its Removal and Potential Implications Regarding the Management of these Wastes

Consistent with the methodology described above for Task 4 (Section 1.7.3), the available CSO data on building stock together with estimated volumes of HBCDD-containing EPS/XPS insulation products was used to estimate the volumes of resulting EPS/XPS insulation wastes likely to arise annually over the next 20 years.

As reported by UNEP[15], the lifespan of polystyrene foam insulation in buildings is reported to be 30-50 years and could exceed 100 years. According to the Irish Concrete Federation[16], *"concrete buildings can have a minimum service life of 50 years, but may remain serviceable for hundreds of years"*.

The National Renovation Strategy *"Better Buildings – A National Renovation Strategy for Ireland and Ireland's Long Term Renovation Strategy 2020"* was also consulted. This Strategy document sets out projections for the future renovation of buildings to meet Ireland's obligations under the EU Directive on Energy Efficiency (2012/27/EU). It is noted that Ireland has one of the newest housing stocks among EU Member States, with a relatively high share (>20%) of housing constructed since 2000[17]. This is likely to impact on the rate of generation of HBCDD-containing EPS and XPS waste in the coming years, when assumptions on the typical age of dwellings is taken into account.

The NIAI was consulted regarding the likely practices involved with the retrofit and upgrade of buildings for energy efficiency, which is likely to comprise a significant proportion of building modifications in the years and decades ahead. This also informed the likely quantity of insulation materials to be removed from the existing building stock as waste.

Estimation of Demolition Activity

The number of buildings demolished each year in Ireland is unconfirmed. In the UK, it has been estimated that 50,000 buildings are demolished every year[18]. According to the UK National Energy Efficiency Action Plan of 2014[19], the total UK building stock comprises 28.8 million buildings (27 m residential, 1.8 m non-residential). This indicates that in a given year, the share of buildings demolished represents 0.2% of the total building stock.

For the purposes of future waste generation scenarios associated with building demolition in Ireland, the following demolition rates have been assumed for three scenarios:

- Scenario 1 - Low Volume: 0.2% (baseline - consistent with latest UK estimate)
- Scenario 2 - Mid-range: 0.3% (50% increase over baseline estimate)
- Scenario 3 - High Volume: 0.4% (100% increase over baseline estimate)

For a building's demolition, it has been assumed that 100% of the walls will be removed while 50% of the floor will be removed. In many demolition projects, it will be possible to retain ground floor slabs in which case the underlying insulation materials will remain undisturbed. In the cases of more significant redevelopment, the floor area may be broken out entirely. On this basis, a 50% rate of removal of floor area has been assumed for building demolition.

Estimated Renovation Activity

The National Renovation Strategy published in 2020 identifies that 0.4-1.2% of the residential building stock in Ireland is renovated each year. The Strategy also identifies the headline retrofit target of 500,000 retrofits to a BER level of B2 (or cost optimal or carbon equivalent) by 2030. This corresponds to approximately 30% of the residential building stock.

For the purposes of future waste generation scenarios associated with building renovation in Ireland, the following rates of renovation have been assumed:

- Scenario 1 - Low Volume: 1.2% (consistent with existing rate)
- Scenario 2 - Mid-range: 15% (50% of National Renovation Strategy headline target)

[15] Technical guidelines on the environmentally sound management of wastes consisting of, containing or contaminated with hexabromocyclododecane, UNEP, 2018

[16] https://www.irishconcrete.ie/backbone-sustainable-construction/society/

[17] Nicol S., Roys M., Ormandy D., Ezratty V. (2016), Briefing Paper - The cost of poor housing in the European Union, BRE (Building Research Establishment), Watford, UK

[18] Architects Journal (2019), Introducing RetroFirst: A new AJ campaign championing reuse in the built environment: https://www.architectsjournal.co.uk/news/introducing-retrofirst-a-new-aj-campaign-championing-reuse-in-the-built-environment

[19] UK National Energy Efficiency Action Plan (2014), UK Department of Energy & Climate Change

- Scenario 3 - High Volume: 30% (National Renovation Strategy target met)

The National Renovation Strategy identifies 'major renovation' as *"the renovation of a building where more than 25% of the surface area of the building envelope undergoes renovation"*. It is therefore assumed that in a typical renovation project, 25% of the total wall area would be removed.

As discussed with the NIAI, renovation works are generally unlikely to include removal of floor slabs / original floor insulation materials. Examples of exceptions to this would include breakout of floor areas where the building layout is altered significantly or existing internal areas are converted for use as external space. Accordingly, the estimated quantity of floor insulation materials removed during a typical renovation project is assumed to be limited to 10%.

Defective Building Materials in Construction

A significant current and future source of building demolition and renovation waste includes the remediation of the building stock impacted by defective building materials, including those properties significantly impacted by pyrite and mica. A review of the available data on these properties has been carried out and is reported in Section 3.2.1.

1.7.5 Benchmarking

The benchmarking process focuses on the legislative framework of three Members States relevant to the management and disposal of HBCDD-containing insulation. The review seeks to identify best practice approaches related to any testing of materials pre-demolition, source segregation requirements, recycling and final disposal requirements. Based on preliminary research and available information, the Netherlands, Denmark and Sweden were selected for this purpose.

2. Approaches in Other Countries

2.1 Netherlands

The Netherlands benchmarking review focused mainly on how the country is working to ensure insulation waste containing HBCDD is managed safely so that the HBCDD can be removed, maximising the potential for the remainder of the insulation to be recycled. The main source of data for the Netherlands is that derived from a study commissioned by the Dutch Ministry of Infrastructure and the Environment in 2016 regarding HBCDD in EPS/XPS waste in the Netherlands[20], as well as information regarding the PolyStyreneLoop project[21], policy documents, papers, and articles.

2.1.1 HBCDD in EPS/XPS waste in the Netherlands

In response to the EU Regulation the Dutch Ministry of Infrastructure and the Environment established an inventory of the volume and concentration levels of HBCDD-containing products and waste streams. As approximately 95% of the HBCDD used in the Netherlands in 2016 was related to the EPS/XPS, the inventory focused on production, use and disposal of HBCDD in EPS/XPS in the period 1960-2016. The study sought to understand:

- How did the waste processing of EPS/XPS take place, including collecting, sorting, separation, incineration, landfill, recycling.
- What was the volume of the various sources of polystyrene waste streams, including construction and demolition (C&D) waste, and waste from civil engineering projects.
- What were the concentration levels of HBCDD in these waste streams.
- Is an effective separation between polystyrene with and polystyrene without HBCDD possible and does it take place in practice?

Information for this study was derived from sources such as literature studies and interviews with experts. Very limited data was found on measured HBCDD concentrations in products and waste streams, and the HBCDD quantities were therefore based on literature data on HBCDD concentration levels.

2.1.2 Regulation

The Netherlands national waste policy can be found in the *Landelijk Afvalbeheersplan* (LAP). In the third version of this Plan (LAP3)[22], specific regulation on EPS was incorporated into Dutch national waste policy for the first time.

The LAP3 has undergone two amendments, the last one came into effect in March 2021. The LAP3 consists of two parts: the first part focuses on the national waste policy in general, while part two, the so-called sector plans, focuses on policies for specific waste categories. A specific sector plan (#85[23]) for EPS is included, defining a minimum standard for the treatment of EPS waste, with and without HBCDD, in accordance with the European POPs Regulation. XPS is not included in sector plan 85 on EPS.

Sector plan 85 covers two EPS waste streams, namely packaging waste and construction and demolition waste. Regarding the latter, the following delineation is given:

- EPS construction and demolition waste is that which has been separated at the building/construction site.
- EPS waste kept separate from civil engineering projects (GWW in Dutch).
- EPS obtained from mixed construction and demolition waste.

[20] *HBCDD in EPS/XPS waste in the Netherlands. Inventory of size and value,* s.l.: Ministry of Infrastructure and the Environment (2016)

[21] https://polystyreneloop.eu/

[22] https://lap3.nl/service/english/

[23] https://lap3.nl/sectorplannen/sectorplannen/eps/

The plan assumes that most EPS waste arises from demolition activities and that in the coming years it will most probably still contain HBCDD at concentration levels equal to or greater than 1,000 mg/kg.

The minimum standard for processing EPS construction and demolition waste

Sector plan 85 states that processing should take place in accordance with the provisions of Regulation (EU) 2019/1021 on POPs (Art. 7.2 and Annex V, Part 1) regarding the disposal of HBCDD. This means that only the following processing methods are allowed for this waste stream:

- D9 (chemical/physical treatment).
- D10 (incineration on land).
- R1 (main use as fuel or other methods to generate energy).

Substances or materials that are residual or recovered in a D9 treatment process, during which HBCDD is separated for destruction, may be recovered or recycled. The separated HBCDD fraction must always be destroyed or irreversibly transformed in a D9 or D10 treatment process.

Processing EPS construction and demolition waste to a higher standard than stipulated by the POPs Regulation, is only allowed for separately collected EPS construction waste for which it can be determined that the EPS waste does not contain HBCDD in concentration levels equal to or greater than 1,000 mg/kg. Currently, EPS from construction, demolition and civil engineering projects often contains too high a concentration of HBCDD and therefore usually falls under category 109 (A or B) of Annex 11 of the *Activiteitenregeling milieubeheer* (Environmental Management Activity Regulations): '*other waste that may not be landfilled (hazardous or non-hazardous)*'.

2.1.3 HBCDD use in the Netherlands

The 2016 study states that HBCDD use in the Netherlands has been relatively high compared to other European countries, due to more stringent safety regulations for buildings. For example, in the Netherlands underground applications of EPS/XPS must contain flame retardants and Dutch insurance policies at that time required flame retardants in EPS/XPS for the construction of storage facilities[24]. The study also highlighted that approximately 60% of EPS used in the construction sector in the Netherlands was used in houses, with the remaining 40% in industrial buildings.

2.1.4 HBCDD concentration levels

According to the 2016 study, typical HBCDD concentration levels for EPS insulation range between 5,000 ppm and 10,000 ppm, while HBCDD concentration levels in XPS fluctuate between 8,000 ppm and 25,000 ppm. As the HBCDD content is fundamental for products to pass required flammability tests, information on the HBCDD concentration levels was generally found in the product's safety data sheets (SDS). For waste streams, however, there was generally no data available on HBCDD concentrations. The inventory therefore used general assumptions on HBCDD concentration levels for products manufactured between 1975 and 2015: 7,000 ppm for EPS and 15,000 ppm for XPS.

In 2018, another study was commissioned by the Netherlands Ministry of Infrastructure and Water Management[25]. The study focused on HBCDD concentration levels in EPS/XPS products and waste streams. With regard to such levels in EPS and XPS construction materials, it was concluded that approximately 70% of the EPS/XPS samples collected from construction and demolition waste contained brominated flame retardants in concentrations higher than 1,000 ppm, with the remaining 30% showing lower concentrations of bromine. The study stated that the most likely explanation for this finding is that some of the EPS/XPS in construction and demolition waste actually concerns packaging waste.

[24] Seppälä, T., 2013. *Presentation of Listing hexabromocyclododecane in Annex A of Stockholm Concention.* u.o.:Finish Environmental Institute

[25] https://www.informea.org/en/hbcdd-concentrations-epsxps-products-and-waste-streams-inventory-netherlands

2.1.5 Quantities of EPS/XPS construction waste

In 2016, approximately 55,750 tonnes of EPS/XPS construction products were placed on the market (i.e. production plus import minus export) with approximately 1,150 tonnes EPS/XPS waste collected from construction and demolition sites and civil engineering projects (both separate collection and mixed)[26]. As stated by Conversio in their report on waste generation, waste quantities and the recycling potential of HBCDD-containing EPS/XPS waste in Europe are relatively low[27], e.g. the total volume of EPS/XPS construction waste in 2018 in the Netherlands amounted to 10 kiloton. Approximately 69% of this amount, i.e. 7 kiloton, contained HBCDD. This report also estimated that approximately 94% of the EPS/XPS construction waste generated in 2018 was incinerated, while the remainder was recycled (5%) or landfilled (1%). Reasons for the poor recycling rate included the relatively low waste volumes, the lack of collection structure and the relatively high transport costs due to the light weight of the material.[28] It is also noted that incineration of this waste stream is in accordance with the requirements of the POPs Regulation.

The following tables estimate future collection volumes of EPS/XPS construction waste in the Netherlands in 2030 and 2050. The majority of this waste stream is expected to be EPS/XPS arising from demolition sites.

Table 2: Future collection volumes of EPS/XPS construction waste in 2030 (The Netherlands)[29]

2030	**Separate collection**		**Mixed waste**		**Total**
	< 1,000 ppm	**> 1,000 ppm**	**< 1,000 ppm**	**> 1,000 ppm**	
Construction sites	200	0	600	0	800
Demolition sites	400	100	1,500	500	2,500
Civil engineering	0	100	0	0	100
Total construction	**600**	**200**	**2,100**	**500**	**3,400**

Table 3: Future collection volumes of EPS/XPS construction waste in 2050 (The Netherlands)[30]

2050	**Separate collection**		**Mixed waste**		**Total**
	< 1,000 ppm	**> 1,000 ppm**	**< 1,000 ppm**	**> 1,000 ppm**	
Construction sites	200	0	600	0	800
Demolition sites	1,700	4,700	6,600	18,800	31,800
Civil engineering	0	400	0	0	400
Total construction	**1,900**	**5,100**	**7,200**	**18,800**	**33,000**

The 2016 study further presents a figure showing the expected trend in EPS/XPS construction waste in the Netherlands to the year 2100 (Figure 2). The volumes of EPS/XPS construction waste containing HBCDD are expected to remain relatively steady from approximately 2015 to 2045, after which the volumes are expected to decrease until insulation waste containing HBCDD phases out around the year 2090. In total, it is estimated that approximately 1,130 kilo tonnes of EPS/XPS containing-HBCDD construction waste will be generated in the Netherlands in the period between 2016 and 2075.

[26] *HBCDD in EPS/XPS waste in the Netherlands. Inventory of size and value,* s.l.: Ministry of Infrastructure and the Environment (2016)

[27] https://polystyreneloop.eu/wp-content/uploads/2021/01/Conversio-study.pdf

[28] https://lap3.nl/sectorplannen/sectorplannen/eps/

[29] *HBCDD in EPS/XPS waste in the Netherlands. Inventory of size and value,* s.l.: Ministry of Infrastructure and the Environment (2016)

[30] *HBCDD in EPS/XPS waste in the Netherlands. Inventory of size and value,* s.l.: Ministry of Infrastructure and the Environment (2016)

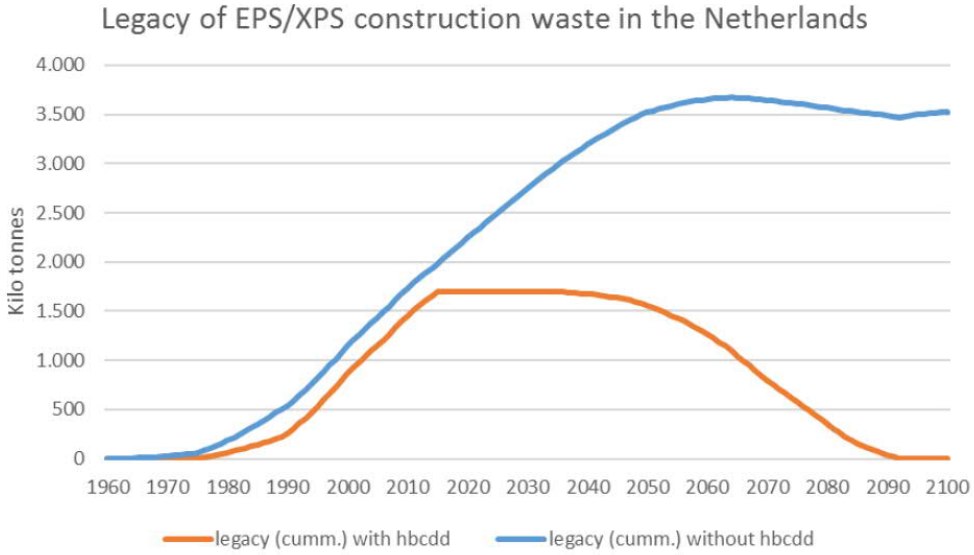


Figure 2: Legacy of EPS/XPS construction waste in the Netherlands[31].

Since 2016 no new data has become available on quantities of HBCDD-containing EPS/XPS insulation waste in the Netherlands. In 2021, a study performed by the Netherlands National Institute for Public Health and the Environment (RIVM)[32] on monitoring EPS waste (among other waste streams) still referred to the 2016 study.

2.1.6 Handling EPS/XPS waste with HBCDD

EPS/XPS construction waste from demolition sites, mostly collected in a mixed waste fraction, is transported to a recycling company who separate waste to recyclables and residual waste. EPS is often not considered as recyclable material since it is usually contaminated and (as stated before) is incinerated.

According to sector plan 85 on EPS[33], market parties are working on two processing techniques that meet the requirements of the POP Regulation regarding the destruction of HBCDD, with simultaneous or subsequent recovery/recycling of the EPS material.

One alternative process, the so-called PolyStyreneLoop (see Box 1 below), involves dissolving the material and separating most of the HBCDD from the EPS for destruction. The remaining polystyrene contains much less HBCDD and may be suitable for recycling. The HBCDD is removed from the solvent, after which the solvent can be reused. The HBCDD is destroyed by incineration, whereby bromine is recovered. This processing of HBCDD-containing EPS by D9 (chemical/physical treatment aimed at separation), followed by D10 (incineration of HBCDD fraction) complies with the POPs Regulation.

Another alternative process focuses on the decomposition of non-recyclable waste into small chemical units. In this process, HBCDD is also broken down and the resulting small chemical molecules can serve as a basis for new products – in this case for the production of methanol. In this alternative, although the polystyrene itself is lost, it is actually converted into another raw material. This processing of HBCDD-containing EPS by D9 (chemical/physical treatment) also complies with the POPs Regulation.

[31] Giraf Results, 2016. *HBCDD in EPS/XPS waste in the Netherlands. Inventory of size and value,* u.o.: Ministry of Infrastructure and the Environment

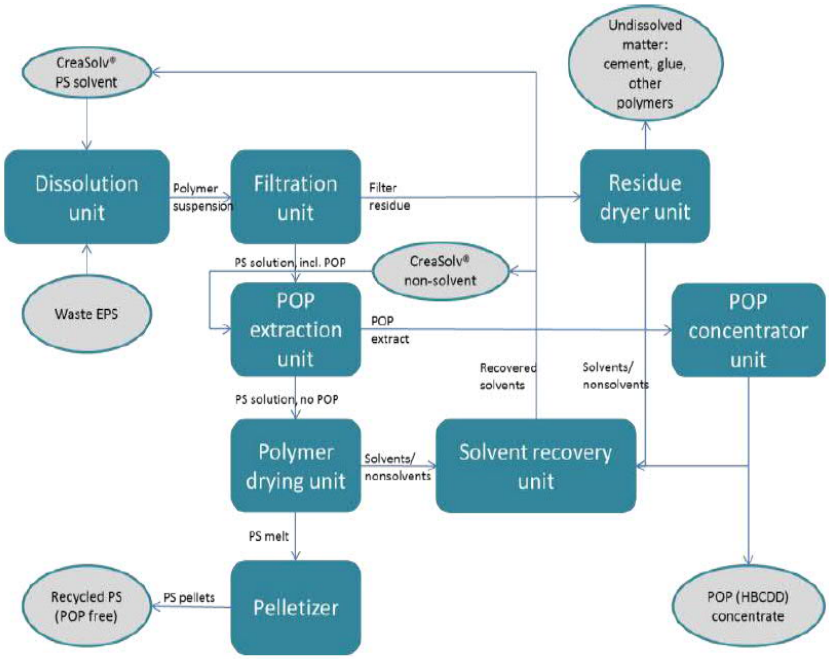
[32] https://www.rivm.nl/publicaties/zicht-krijgen-op-zeer-zorgwekkende-stoffen-in-circulaire-economie-concretisering-van

[33] https://lap3.nl/sectorplannen/sectorplannen/eps/

When the abovementioned waste treatment processes become commercially viable on the market and the requirements for raising the minimum standard (in accordance with the provisions of LAP3, section D.2.3[34]) are met, the minimum waste treatment standard could be amended. This means that incineration, with or without energy recovery, may no longer be the preferred treatment route.

Box 1 – PolyStyreneLoop

The PolyStyreneLoop Cooperative is a non-profit organisation with over 70 members representing the entire polystyrene foam sector, including manufacturers, suppliers, and recyclers (PolyStyreneLoop, 2022). The objective of the organisation is the recycling of polystyrene insulation foam waste with the recovery of bromine, with a demonstration plant established for the new waste treatment process.



The demonstration plant is located in Terneuzen, Netherlands, with an annual intake capacity of 3,300 tonnes.

In 2017, the Basel Convention General Technical Guidelines recognised the PolyStyreneLoop process as a valid pre-treatment process for separating polystyrene and HBCDD in insulation waste. It is also included as a best available waste treatment technique (BAT) for the destruction of HBCDD.

According to a news message on their website, PolystyreneLoop B.V. fell into bankruptcy on 8th March 2022. It was stated that implementation of the scale-up of the new innovative technology from pilot scale was expected to be challenging and that the attempted start-up was delayed by a number of unexpected issues. The unprecedented events of recent years, including COVID-19 related delays and soaring energy prices, also contributed to severely impact liquidity

(source: https://polystyreneloop.eu/news/bankruptcy/).

In June 2022, it was announced that the PolyStyreneLoop demonstration plant was reopened following the purchase of the plant by a consortium of German companies with a newly established company named PS Loop B.V., a 100% subsidiary of the GEC Group.

(source: https://polystyreneloop.eu/news/launch-ps-loop/)

[34] Section D.2.3 covers the raising of minimum standards during the period of validity of the LAP3: https://lap3.nl/publish/pages/121404/lap3_d02_minimumstandaard_02-03-2021.pdf

2.2 Sweden

Sweden has implemented complementing domestic regulations (to the EU POPs Regulation) through the Swedish Waste Ordinance (SFS 2020:614, 2020) and the Planning and Building Act (2010:900, PBL). Consequently, for the substances covered in the POPs Regulation, waste is automatically considered as hazardous when concentrations of the substance are above the specified thresholds set out in Annex IV of the Regulation[35].

2.2.1 Hazardous waste in the Swedish Waste Ordinance (2020:614)

If classified as hazardous waste, the producer must manage insulation waste containing HBCDD in an environmentally sustainable manner, including source separation of hazardous waste streams, with documentation and reporting of hazardous waste amounts. Producers involved in construction and demolition for example, must separate construction and demolition (C&D) waste into a minimum of six streams, in addition to as many hazardous waste streams as necessary. Any waste that is not source separated can only be incinerated. EPS/XPS containing HBCDD must either be collected as a separate stream if classified as hazardous, or can be recycled as plastic if non-hazardous.

Anyone who produces or handles hazardous waste has an obligation to report quantities produced in accordance with waste codes to a digital waste register maintained by the Swedish Environmental Protection Agency (EPA). The obligation to report hazardous waste is regulated through Chapter 6 *Traceability of hazardous waste* (Swedish: Spårbarhet för farligt avfall).

2.2.2 Planning and Building Act (2010:900, PBL)

Insulation materials containing HBCDD are subject to regulation in Sweden through the Planning and Building Act which seeks to control its arisings in the building and demolition sector. *Chapter 10: The implementation of construction, demolition and land measures* of the Act requires a c*ontrol plan* to be prepared by the developer in advance of waste being produced and this plan must outline, the type and quantities of waste to be generated and how the waste will be managed with a focus on enabling the removal and safe management of hazardous substances.

2.2.3 HBCDD in EPS/XPS

Import of HBCDD to Sweden peaked at around 120 tonnes per year in 1997. Importation in the form of plastic raw material for the manufacturing of EPS declined sharply to 263 kg in 2015 before the cessation of imports in 2016. The industrial use of HBCDD has been strictly regulated, with the result that HBCDD input to Sweden now mainly consists of the import of products from countries with less restrictions.

XPS containing HBCDD was used in the railroad network for the protection from freezing in northern Sweden in the period of 1970-2000. The quantity of this material in use in railroads was estimated to be around 200 tonnes HBCDD. (Banverket, 2006) with more recent data not currently available.

2.2.4 Waste management

Guidelines have been published with the aim of assisting waste producers in the identification of material potentially containing HBCDD in construction and demolition waste; *Resource and Waste Guidelines for Construction and Demolition* and *The Building Reuse Guide*. These are discussed hereunder. In general, EPS/XPS waste containing HBCDD is sent for incineration.

[35] Regulation (EU) 2019/1021

Resource and Waste Guidelines for Construction and Demolition
(Resurs- och avfallsriktlinjer vid byggande och rivning)

The Swedish industry and employer organisation for construction companies *Byggföretagen* has developed general guidelines on how the Swedish construction sector should manage waste, with the objective of developing industry standards which enable more circular and sustainable resource and waste flows[36]. The guidelines contain several annexes, of which two (Annexes 1 and 12) focus on hazardous waste. Annex 1 outlines a list of hazardous waste streams including examples of substances with hazardous properties, examples of materials and products which may contain the hazardous substances, suggestions on waste codes, and a description of management techniques in accordance with legal requirements and industry standards. According to the list, insulation containing brominated flame retardants, including HBCDD, should in most cases be regarded as hazardous waste and incinerated in an approved facility (Byggföretagen, 2021).

The guidelines state that a material inventory (Swedish: Materialinventering) is required before construction and demolition works commence in order to identify which potential materials can be reused. Hazardous materials require particular consideration, with the location of these materials and estimate of quantities to be identified.

A material and waste management plan is to be prepared using the material inventory, with the appointed contractor setting out the management procedures and outlets for the various waste streams. The guidelines include a procedure for handling hazardous waste (Annex 12) and are based on the Swedish building certification *BF9K*[37]. The material inventory is to be prepared in both renovation and demolition projects, by a person with documented knowledge and experience in identifying hazardous waste that will be produced in the project. The inventory is subsequently used to produce a site or project specific waste management plan. The waste management plan in turn informs the control plan (described above) for building or demolition permits or notifications.

The Building Reuse Guide (Byggåterbruksguiden)

The building reuse guide was developed by the Swedish Waste Management Association (Swedish: Avfall Sverige) and the Swedish Environmental Research Institute (IVL) with the purpose of increasing awareness around the potential reuse of construction and demolition waste. It provides a simple evaluation of construction product groups and their reusability based on approximate manufacture and/or assembly date. These factors are used as a key indicator to assess the risk of potentially hazardous substances, with some 70 products included.

The guide simplifies material assessments, outlines how visual screening of materials for their reuse can be done and points to materials / product categories that should be phased/incinerated due to hazardous substances. The following hazardous substances are included in the evaluation –

- Asbestos
- Metals: lead (Pb), cadmium (Cd), chromium (Cr), copper (Cu), nickel (Ni), zinc (Zn), arsenic (As) and mercury (Hg)
- Chlorinated paraffins, short chain (SCCP)
- PAHs (polycyclic aromatic hydrocarbons)
- CFCs / HCFCs (chlorofluorocarbons and hydrogen fluorocarbons)
- Hydrocarbons (C6 - C36,) (aliphatic hydrocarbons)
- PCBs (polychlorinated biphenyls, including 209 PCBs)
- Brominated flame retardants (hexabromocyclododecane).

A colour coded system is used to classify the materials and how they should be manged.

[36] Byggföretagen, 2021. *Bilaga 1 Lista över farligt avfall FA,* u.o.: u.n.

[37] Anon., 2022. *BF9K.* [Online] Available at: https://bf9k.se/

Green: can be reused (low hazardous content)

Yellow: evaluation is required, may contain hazardous substances (medium)

Red: do not reuse, contains hazardous substances (high)

All polystyrene insulation material (Figure 3) arising from renovation/demolition works on roofs, facades, foundations, ceilings, floors and inner walls manufactured before 2015 are classified as hazardous by default. Post 2015, the insulation waste can potentially be re-used.

Takkonstruktion

Inga problem att återanvända i driftsfasen | Utvärdering behövs, kan innehålla farliga ämnen | Ska inte återanvändas, innehåller farliga ämnen

Produkt	Kan återanvändas?	Bygg-/tillverkningsår	Farligt innehåll	Information och tips
Isolering (polystyren)	☹	– 1969	Bromerade flamskydds-medel	Isolering av polystyren som är producerad före 2015 ska undvikas då det kan förekomma HBCDD, ett giftigt bromerat flamskyddsmedel, i produkten. I polystyren producerad 1970-1997 kan det också förekomma freoner. Detta kan orsaka problem vid bearbetning, skärning och sönderdelning eftersom gaserna kan släppas ut i atmosfären där de bidrar till att tunna ut ozonskiktet. Vänd dig till din kommun för att få information om hur du ska sortera avfallet.
	☹	1970-1997	Bromerade flamskydds-medel, freoner	
	☹	1998-2015	Bromerade flamskydds-medel	
	😐	2016-2021	Klorfluor-karboner (CFC) och hydroklor-fluorkolväten (HCFC)	

Figure 3: Building Reuse Guide construction products[38]

[38] IVL Swedish Environmental Research Institute, 2022. *Byggåterbruksguiden. En vägledning för att underlätta återbruk av byggprodukter i bostäder,* u.o.: Avfall Sverige

2.3 Denmark

The benchmarking review of Denmark focused on reports on HBCDD and brominated flame retardants published by the Danish EPA (Miljøstyrelsen) and considered the following.

- Strategy for risk management of brominated flame retardants conducted by the Danish EPA.
- Destruction of POPs at conventional waste incineration plants for incineration of primarily non-hazardous waste.
- Knowledge sharing via a digital platform on demolition waste containing HBCDD.

2.3.1 Regulation

As for other EU Member States, POPs are regulated though the EU Regulation outlined earlier in this report. Domestic legislation on hazardous waste is enforced through the Danish Statutory order on Waste (BEK nr 2159 av 2020-12-09). This requires the classification process to be performed by the producer of waste, with municipalities having the right to decide if a particular waste stream is to be considered as hazardous. Producers involved in construction and demolition must at a minimum, separate waste into 10 no. waste streams if the total of waste quantity to be generated exceeds 1 tonne. Additionally, all hazardous waste streams must be separated.

2.3.2 HBCDD in EPS/XPS

LOUS is the Danish EPA's *List of Undesirable Substances* intended as a guide for businesses on substances that should be used less in the long term or completely phased out. It allows businesses to stay one step ahead of regulation and replace 'substances of concern' before they are banned. The LOUS contains 40 substances and substance groups including brominated flame retardants.

Substances are included in LOUS if they have a number of undesirable effects and are used or have been used in significant quantities in Denmark. The 2014 survey on HBCDD use in Denmark (as part of LOUS) indicated that the main application between 1999 and 2012 was the production of flame-retardant polyurethane foams for building insulation and packaging for electronics.

Total consumption for production in Denmark was identified as approximately one tonne in 2012[39] which was down from an estimated 6-13 tonnes in 1999. This reduction was attributed to the fact that fire safety regulations did not require the use of flame-retardant EPS or XPS in buildings constructed in Denmark. However, the 2014 survey did highlight that the consumption of flame-retardant EPS in Denmark appeared to be increasing for the construction of new "zero energy" houses, wherein the walls are built of flame-retardant EPS blocks covered with a non-combustible material. The flame-retardant EPS for this purpose was imported.

2.3.3 Management of HBCDD-containing waste

The primary management route for HBCDD-containing waste in Denmark is incineration. An investigation was conducted by the Danish EPA in 2019[40] into the potential destruction levels of certain POPs at non-hazardous waste incineration plants. Results indicated that in some cases, more than 99.9% of the HBCDD was destroyed when the temperature in the afterburner chamber was above 900-1000°C. This level of destruction was reported for concentrations of up to 0.02% of HBCDD in polystyrene with Refuse Derived Fuel (RDF). The report states that although there are no studies on increased concentration of PCDD/F, PBDD/F or PBCDD/F in slag and residues due to combustion of HBCDD, an increase of these concentrations can be expected. Based on available studies, it is expected that Danish emission limit values for dioxins in

[39] Lassen, C. et al., 2014. *Survey of brominated flame retardants. Part of the LOUS-review. Environmental Project No. 1536, 2014,* Copenhagen: The Danish Environmental Protection Agency

[40] Miljøprojekt 2019. *Belysning af destruktion af visse POPstoffer på konventionelle affaldsforbrændingsanlæg til forbrænding af hovedsageligt ikkefarligt og forbrændingsegnet affald*

flue gas[41] can be met if the proportion of HBCDD-containing material co-combusted with other waste is limited to no more than 2% total content. Destruction achieved above this level (2% total content) is unknown.

2.3.4 Awareness Initiatives

The Danish Knowledge Centre for Circular Economy in Construction (https://vcob.dk/) is a digital platform which provides information about circular economy in the construction sector to stakeholders such as building owners, contractors, architects, consultants, manufacturers, and municipalities.

The web-based platform includes a section on demolition and building waste, with a specific focus on hazardous substances (https://vcob.dk/vcob/nedrivning/hvad-er-byggeaffald/miljoefarlige-stoffer/organiske-stoffer/) including brominated flame retardants (VCØB, 2022), answering questions such as:

- what are brominated flame retardants?
- where are the brominated flame retardants typically used?
- why are the brominated flame retardants problematic?
- what happens to brominated flame retardants in waste?

In addition to providing general information on brominated flame retardants and HBCDD, the knowledge platform also contains several guides for circular building and demolitions, directed to different stakeholders. One of the guides is directed at contractors working in renovation and demolition and focuses on issues such as how the waste should be handled and recycled (VCØB, 2022). The guide also directs the reader to several documents addressing hazardous substances, specifically a guide for craftsmen regarding hazardous content in built in materials (VCØB, u.d.), and a checklist for risks of hazardous substances (VCØB, u.d.). Included in the guide and checklist are a list of common hazardous substances, where they can be found in buildings, who is responsible for identifying hazardous substances and waste management in a demolition project, and where to find more information.

[41] 0.1 ng I-TEQ/Nm^3(std)

3. Key Project Findings

3.1 Estimated Total Annual Volumes of HBCDD-containing EPS and XPS Insulation Materials Supplied Within the State

3.1.1 Project Survey

The project survey (Section 1.7.2) did not yield responses from the main, relevant stakeholders identified. Knowledge gaps observed during the study are further described in Section 4.

3.1.2 Sectoral Knowledge - NIAI

The key findings relevant to the study from consultation with the NIAI are documented in Table 4 below.

Table 4: Key findings – NIAI consultation

Project Aspect	Known Information
Manufacture of EPS/XPS in Ireland	While supplied for use in the Irish market, no EPS or XPS products containing HBCDD are known to have been manufactured in Ireland.
Market demand – EPS / XPS	The demand for XPS materials in Ireland for the period of investigation is understood to have been minimal if not negligible. However, the introduction of the Building Control Regulations in 1991 (S.I. No. 306 of 1991) resulted in a major increase in demand for EPS insulation materials. This was in response to Part L of the First Schedule of the Regulations on the conservation of fuel and energy which introduced the first prescriptive energy efficiency requirements for buildings in Ireland. Prior to the introduction of these Building Regulations (Part L), EPS insulation materials were previously not a significant input to the insulation market in Ireland.
Source of imports for EPS	For the period of investigation, imports of EPS are known to have been sourced mainly from Germany and also the Netherlands.
HBCDD content	As a commonly used fire retardant, the understanding of the NIAI is that all EPS insulation materials supplied during the period of investigation are likely to contain HBCDD. While the exact HBCDD content for a given product was unknown, SDS or MSDS may remain available from the period of investigation though no MSDS/SDS corresponding to a specific product confirmed to have been supplied in the Irish market was identified.
Market penetration	Further to the introduction of the Building Regulations (Part L) on the 4 December 1991 (effective from 1 June 1992), the % share of EPS insulation materials used in buildings (residential at least) is understood to have increased rapidly from a negligible or low base to approximately 80-85%. This remained broadly consistent from 1991 to approx. 2005. From approx. 2005 onwards, the market share for EPS insulation materials reduced significantly due to an increased demand for PIR (polyisocyanurate) based insulation materials. Between 2005-2016, the estimated % share of EPS insulation materials used in buildings (residential at least) is understood to have dropped to approx. 20-25%.
Typical application of EPS in residential building insulation	While building techniques and application of insulation materials may have varied, insulation quantities for a typical house were estimated as follows: - 40-60 mm EPS insulation for external walls - 50 mm EPS insulation for ground level floors - Typical density of insulation materials 15 kg/m^3. Noted that insulation products varied significantly. Internet searches for SDSs indicate a wide range in product density in the range 8.5-60 kg/m^3.

Project Aspect	Known Information
Future waste arising	The removal of EPS insulation materials is likely to only arise in the case of building demolition. Energy upgrades of the housing and commercial building stock will be largely focused on the addition rather than replacement or removal of existing insulation materials. Removal of floor insulation materials should only arise in very limited cases i.e. involving full building demolition, new basement level construction etc.

3.1.3 Estimated Volumes based on Market Demand and Construction Activity during Period of Investigation

In the absence of responses to the stakeholder survey, an alternative methodology for estimation of volumes of HBCDD-containing EPS and XPS insulation materials supplied in Ireland was utilised as described in Section 1.7.3. This review has focused on the market demand for EPS/XPS insulation materials in the residential sector during the period of investigation (1990-2016).

The CSO housing statistics used for the purposes for the current study are detailed in Appendix 1. This includes the number of residential buildings and floor area, categorised by period of construction and building type for the period of investigation. Further to the identification of relevant building floor areas, the associated wall areas requiring insulation were estimated as detailed in Appendix 2. .

Based on the evaluation detailed in Appendices 1 and 2, it is estimated that a total of 7-8 million m^3 of insulation products was required to meet the demand of new residential buildings in Ireland during the period of investigation. Certain adjustments may be required to this quantity to include for renovation of existing buildings and wastage such as off-cuts from construction works. Furthermore, the corresponding demand for non-residential buildings including public sector, commercial and industrial buildings has not been estimated owing to the significant variation in building type, design, height and insulation requirements.

Market Demand for HBCDD-containing EPS and XPS Insulation Products

Further to consultation with the NIAI, the market share of EPS and XPS insulation products has also been considered in order to estimate volumes associated with HBCDD-containing EPS/ XPS insulation materials, as a subset of the total insulation demand described above.

As noted in Table 4, NIAI feedback suggests that the market share for EPS insulation products was approximately 80-85% during the period 1991-2005/’06 corresponding with the Building Regulations (Part L) in force at the time, subsequently falling to 20-25% between 2005/’06-2016 with a transition to the use of PIR products.

The market share for XPS materials is understood to have been low relative to EPS. In the absence of known market share, a share of 10% has been assumed for the period 1991-2005/’06 and 5% between 2005/’06-2016, in line with the transition to PIR products as described above.

Using the aforementioned figures for the market share of EPS and XPS insulation, the estimated volumes of EPS and XPS insulation materials supplied within the State for use in new dwellings during the period of investigation are shown in Table 5 (values rounded to nearest thousand or hundred-thousand for values > 0.1 million).

Table 5: Estimated volumes of EPS/XPS insulation materials – new dwellings (1991-2016)

Insulation Materials in New Dwellings (1991-2016)	Period of Construction				
	1991-2000	2001-2005	2006-2011	2011-2016	Total 1991-2016
Total Volume – All Insulation (m^3)	**2.3-2.5 million**	**2.5-2.8 million**	**1.8-2.0 million**	**0.5-0.6 million**	**7.3-7.9 million**
EPS					
Estimated Market Share – EPS (%)	85%	85%	25%	25%	
Total Volume – EPS Insulation (m^3)	**2-2.2 million**	**2.2-2.4 million**	**0.4-0.5 million**	**135,000-145,000**	**4.7-5.2 million**
Annual Average – EPS Insulation (m^3)	199,000-216,000	438,000-474,000	76,000-83,000	22,000-25,000	298,000-323,000
XPS					
Estimated Market Share – XPS (%)	10%	10%	5%	5%	
Total Volume – XPS Insulation (m^3)	**234,000-254,000**	**258,000-279,000**	**91,000-100,000**	**26,000-29,000**	**611,000-661,000**
Annual Average – XPS Insulation (m^3)	23,000-26,000	51,000-56,000	15,000-17,000	4,000-5,000	38,000-42,000

In the absence of supply side data and following consultation with NIAI, it is understood that all EPS and XPS insulation products supplied in Ireland during the period of investigation are likely to have contained HBCDD. This is supported by the findings of research[42] by the University of Birmingham in 2018 which detected HBCDD in 100% of C&D EPS and XPS waste materials sampled. The near universal use of HBCDD in such products is also consistent with the findings of the benchmarking review carried out for selected EU Member States (Section 2), which links the use of insulation containing HBCDD to fire safety requirements set out in the country specific Building Regulations at that time. Therefore, it is estimated that 4.7-5.2 million m^3 of EPS insulation materials and approximately 600,000-700,000 m^3 of XPS insulation materials containing HBCDD were supplied in the Republic of Ireland for the purposes of constructing new dwellings during the period of investigation (values rounded to nearest hundred-thousand).

The annual average volumes supplied during the period of investigation are also shown in Table 5 above. The variance in annual average is most significantly influenced by the changes in level of construction activity and the change in market demand which occurred for EPS and XPS products, as currently understood.

3.2 Estimated Volumes of HBCDD-containing EPS and XPS Insulation Wastes Arising Annually Over the Next 20 Years

Based on the estimated volumes supplied in Ireland as set out in Section 3.1.3 above, projections of the estimated volumes of HBCDD-containing EPS and XPS insulation wastes arising annually over the next 20 years have been determined using the methodology set out in Section 1.7.4.

As the estimated supply volumes for the non-residential sector remain unknown, the estimated volumes of waste arising as reported below are also limited to the waste associated with the residential building sector.

Three scenarios have been developed for the estimation of future waste volumes arising as set out in Section 1.7.4 and summarised in Table 6 below.

These scenarios relate to levels of demolition and renovation activity which may occur in the construction sector and are based on assumed levels of modifications to the building stock, whether as a result of demolition or renovation. The levels of these activities likely to occur in future years is likely to be highly variable and subject to a variety of influences including prevailing economic conditions, location (urban/rural), progress in retrofitting the building stock for energy efficiency/upgrades, individual building requirements and design approaches to redevelopment (e.g. complete demolition vs. retention of building fabric) etc.

Table 6: Scenarios for future waste generation associated with building stock demolition and renovation

Scenario	Activity	% Building Stock	% Volume Insulation Removed	
Scenario 1 Low Volume	Demolition	0.2%	Wall	100%
			Floor	50%
	Renovation	1.2%	Wall	25%
			Floor	10%
Scenario 2 Midrange	Demolition	0.3%	Wall	100%
			Floor	50%
	Renovation	15%	Wall	25%
			Floor	10%
Scenario 3 High Volume	Demolition	0.4%	Wall	100%
			Floor	50%
	Renovation	15%	Wall	25%
			Floor	10%

[42] Drage et al., 2018. Brominated Flame Retardants in Irish Waste Polymers: Concentrations, legislative compliance, and treatment options.

An unknown factor in future demolition/renovation activity is the relationship between the period of construction and year of demolition or renovation i.e. it is not expected that the timing of future demolition and renovation activities will correspond in a linear manner to a particular building age. Rather, it is more likely that demolition and renovation works will be undertaken based on the capacity (including financial) and motivation of the owner to carry out such works based on the energy efficiency and comfort levels afforded by the existing building.

In Ireland, energy efficiency grant and support schemes are designed to support energy efficiency upgrades to houses built before 2006 (and installation of renewables in houses built before 2011). Building Regulations introduced from 2006 required an improved level of energy performance. It is considered most likely that over the coming twenty years, demolition and renovation works will be focused on dwellings with a year of construction prior to 2006. The projected waste volumes arising are therefore estimated based on the scenarios set out in Table 6 as applied to the total residential building stock construction during the period of investigation, excluding those buildings constructed since 2006 which are unlikely to be significantly altered by way of demolition / renovation in the coming 20 years.

For each of the scenarios identified in Table 6, the estimated volumes of waste insulation material arising annually due to building and renovation activity is set out in Table 7, Table 8 and Table 9. The typical volumes of wall and floor insulation are as determined in the preceding Section 3.1.3 and Appendices 1-2.

Table 7: Scenario 1 – Estimated volumes of insulation waste for period of investigation (1990-2016)

Typical Volume of Insulation by House Type		**New Dwellings 1991-2006**	**Units Demolished (0.2%)**	**Units Renovated (1.2%)**	**Waste Insulation Volume (m^3)**		
						Demolition	**Renovation**
Detached	Wall (5.1-6.7 m^3)	216,745	433	2,601	Wall	2,211-2,904	3,316-4,357
	Floor (8.1-8.9 m^3)				Floor	1,756-1,929	2,107-2,315
Semi-detached	Wall (2.9-3.1 m^3)	157,055	314	1,885	Wall	911-974	1,366-1,461
	Floor (5.1-5.2 m^3)				Floor	801-817	961-980
Terrace	Wall (0.9-2.0 m^3)	53,193	106	638	Wall	96-213	144-319
	Floor (4.2-4.7 m^3)				Floor	223-250	268-300
Apartment	Wall (1.6-2.2 m^3)	77,841	156	934	Wall	249-343	374-514
	Floor (3.3-3.7 m^3)				Floor	257-288	308-346
Total		**504,834**	**1,010**	**6,058**		**6,503-7,717**	**8,844-10,591**

For Scenario 1, the total estimated volume of waste insulation arising annually as a result of demolition and renovation activities is in the range of 15,000-18,500 m^3. Based on the market demand for EPS and XPS insulation as understood for the period in question, this corresponds to estimated volumes of HBCDD-containing EPS and XPS insulation materials as follows:

- Scenario 1 - HBCDD-containing EPS insulation annual waste arising: 12,750-15,725 m^3
- Scenario 1 - HBCDD-containing XPS insulation annual waste arising: 1,500-1,850 m^3

Table 8: Scenario 2 – Estimated volumes of insulation waste for period of investigation (1990-2016)

Typical Volume of Insulation by House Type		New Dwellings 1991-2006	Units Demolished (0.2%)	Units Renovated (1.2%)	Waste Insulation Volume (m^3)		
						Demolition	Renovation
Detached	Wall (5.1-6.7 m^3)	216,745	650	32,512	Wall	3,316-4,357	41,452-54,457
	Floor (8.1-8.9 m^3)				Floor	2,633-2,894	26,335-28,935
Semi-detached	Wall (2.9-3.1 m^3)	157,055	471	23,558	Wall	1,366-1,461	17,080-18,258
	Floor (5.1-5.2 m^3)				Floor	1,201-1,225	12,015-12,250
Terrace	Wall (0.9-2.0 m^3)	53,193	160	7,979	Wall	144-319	1,795-3,989
	Floor (4.2-4.7 m^3)				Floor	335-375	3,351-3,750
Apartment	Wall (1.6-2.2 m^3)	77,841	234	11,676	Wall	374-514	4,670-6,422
	Floor (3.3-3.7 m^3)				Floor	385-432	3,853-4,320
Total		**504,834**	**1,515**	**75,725**		**9,755-11,576**	**110,551-132,382**

For Scenario 2, the total estimated volume of waste insulation arising annually as a result of demolition and renovation activities is in the range of 120,000-144,000 m^3. Based on the market demand for EPS and XPS insulation as understood for the period in question, this corresponds to estimated volumes of HBCDD-containing EPS and XPS insulation materials as follows:

- Scenario 2 - HBCDD-containing EPS insulation annual waste arising: 102,000-122,400 m^3
- Scenario 2 - HBCDD-containing XPS insulation annual waste arising: 12,000-14,400 m^3.

Table 9: Scenario 3 – Estimated volumes of insulation waste for period of investigation (1990-2016)

Typical Volume of Insulation by House Type		New Dwellings 1991-2006	Units Demolished (0.2%)	Units Renovated (1.2%)	Waste Insulation Volume (m^3)		
						Demolition	Renovation
Detached	Wall (5.1-6.7 m^3)	216,745	867	65,024	Wall	4,422-5,809	82,905-108,914
	Floor (8.1-8.9 m^3)				Floor	3,511-3,858	52,669-57,871
Semi-detached	Wall (2.9-3.1 m^3)	157,055	628	47,117	Wall	1,822-1,947	34,159-36,515
	Floor (5.1-5.2 m^3)				Floor	1,602-1,633	24,029-24,501
Terrace	Wall (0.9-2.0 m^3)	53,193	213	15,958	Wall	191-426	3,591-7,979
	Floor (4.2-4.7 m^3)				Floor	447-500	6,702-7,500
Apartment	Wall (1.6-2.2 m^3)	77,841	311	23,352	Wall	498-685	9,341-12,844
	Floor (3.3-3.7 m^3)				Floor	514-576	7,706-8,640
Total		**504,834**	**2,019**	**151,450**		**13,007-15,434**	**221,103-264,764**

For Scenario 3, the total estimated volume of waste insulation arising annually as a result of demolition and renovation activities is in the range of 234,000-280,500 m^3. Based on the market demand for EPS and XPS insulation as understood for the period in question, this corresponds to estimated volumes of HBCDD-containing EPS and XPS insulation materials as follows:

- Scenario 3 - HBCDD-containing EPS insulation annual waste arising: 198,900-238,425 m^3
- Scenario 3 - HBCDD-containing XPS insulation annual waste arising: 23,400-28,050 m^3.

In summary, the estimated volumes of HBCDD-containing EPS and XPS insulation wastes arising annually from the residential building sector (attributed to the period of investigation) are as shown in Table 10. As the annual variation is likely to be significant, the summary values tabulated below have been rounded to the nearest 500 m^3.

Table 10: Summary of estimated volumes of HBCDD-containing EPS and XPS insulation waste (1990-2016)

HBCDD-containing Insulation Waste	Scenario 1 Low Volume	Scenario 2 Mid-range	Scenario 3 High Volume
EPS (m^3)	12,500-16,000	102,000-122,500	198,500-238,500
XPS (m^3)	1,500-2,000	12,000-14,500	23,000-28,500

As stated previously, the above estimates are attributed to waste arising from the residential building stock constructed during the period of investigation. Knowledge gaps remain in relation to (i) the quantity of HBCDD-containing EPS/XPS insulation used in the commercial, industrial and public sector building stock, and (ii) the presence of HBCDD-containing EPS and XPS materials used in the building sector prior to 1990/'91.

3.2.1 Remediation of Buildings Impacted by Defective Construction Materials

Pyrite

The issue of pyrite-related defects in building construction in Ireland was first raised in 2007, attributed to quarries unknowingly supplying large volumes of hardcore material with excess pyrite to builders. This hardcore material was in turn used as infill for foundations in the construction of new homes. The infill material sits under the concrete slab of the property. Problems arise when the pyrite oxidises and forms gypsum which occupies more space than pyrite and so swells and pushes up against the slab. The resulting impacts on the structural integrity of affected structures has necessitated significant remedial building works.

The Report of the Pyrite Panel of June 2012[43] identified an upper estimate 10,300 properties requiring remediation in the counties of Meath, Kildare and Offaly and the administrative areas of Fingal County Council and Dublin City Council, further to properties impacted by pyrite where remediation had already been completed. The period of construction of the affected properties was identified as between 1997-2009, with a majority of affected properties constructed between 2002-2006. It is therefore likely that many of these properties were constructed using HBCDD-containing EPS/XPS insulation materials.

In 2015, the administrative areas of South Dublin County Council (SDCC) and Dún Laoghaire-Rathdown County Council (DLRCC) were added to the Pyrite Remediation Scheme. The administrative area of Limerick City and County Council (LCCC) was also added to the Scheme in September 2020. The estimated number of properties impacted in the administrative areas of these latter local authorities (SDCC, DLRCC and LCCC) is unknown. The most recently published Annual Report of the Pyrite Resolution Board for 2021 identifies that a total of 2,292 dwellings have had works completed and certified since the Scheme's launch, with contracts in place for a further 121 dwellings.

It is therefore estimated that approximately 7,900 properties may yet require remediation though individual property impacts will vary whereby some properties will require no significant remediation and others more severely impacted will require major remedial works.

While the remediation of pyrite damage will generally not involve the complete demolition of affected buildings, it is likely that concrete floors will be taken up with underlying fill material replaced and the floor reinstated. The associated waste insulation volumes likely arising due to such remediation are estimated in Table 11, conservatively based on the largest dwelling type (detached), 100% of floor slab demolition and up to 25% of wall insulation removal.

[43] https://www.pyriteboard.ie/Pyrite/media/Pyrite/Updated/Report-of-Pyrite-Panel-June-2012.pdf

Table 11: Estimated volumes of HBCDD-containing EPS and XPS insulation waste - dwellings impacted by pyrite

Typical Volume of Insulation by House Type		Dwellings Affected	Units Remediated (100%)	Waste Insulation Volume (m^3)	
					Remediation
Detached	Wall (5.1-6.7 m^3)	7,900	7,900	Wall	10,073-13,233
	Floor (8.1-8.9 m^3)			Floor	63,990-70,310
				Total	74,063-83,543
Estimated HBCDD-containing EPS insulation waste (max. 85%) [Estimated range to nearest 500 m^3]					**62,953-71,011 [62,500-71,000]**
Estimated HBCDD-containing XPS insulation waste (max. 10%) [Estimated range to nearest 500 m^3]					**7,406-8,354 [7,000-8,500]**

It is considered that the above volumes represent a worst-case, conservative estimate as an unknown proportion of dwellings impacted by pyrite and Mica will have been constructed without the use of HBCDD-containing insulation materials. The annual quantities will be subject to variation and may warrant further consultation or engagement with the Pyrite Resolution Board.

Mica

The Report of the Expert Panel on Concrete Blocks of 2017 was prepared in response to the issue of mica occurrence in defective concrete blocks used in the construction of dwellings, mainly in the northwest of Ireland, specifically the counties of Donegal and Mayo. For the county of Donegal, the report estimated that a likely minimum number of 1,200 dwellings were impacted by mica with a potential for up to 4,800 properties. In Mayo, it was estimated that 345 dwellings were likely impacted. The period of construction of affected dwellings has been identified as 1988 to 2009, with a majority of affected properties construction during the period 1999-2009. It is therefore likely that many of these properties were constructed using HBCDD-containing EPS/XPS insulation materials.

Further to the expert report of 2017, a Defective Blocks Grant Scheme for the remediation of impacted properties was subsequently introduced. An enhanced scheme was made effective by way of legislation in 2022. In March 2022, the Report of the Expert Group on the Enhanced Defective Concrete Blocks Grant Scheme identified that additional properties in the counties of Clare, Sligo, Limerick and Tipperary may also be impacted. It is understood that no estimation of the likely number of affected dwellings in these counties has been carried out as yet. The Remediation of Dwellings Damaged by the Use of Defective Concrete Blocks Act 2022 (Act No. 28 of 2022) was signed into law by the President on 23 July 2022 and provides the basis for the enhanced grant scheme for remediation of impacted properties in the local authority areas of Clare, Donegal, Mayo, Limerick City and County.

For the counties of Donegal and Mayo at least, it has been estimated that between 1,545 and 5,145 properties may require remediation though individual property impacts will vary whereby some properties will require no significant remediation and others more severely impacted will require major remedial works. The upper end of the range is based on the findings of the Report of the Expert Panel on Concrete Blocks of 2017, with 1,545 considered the likely minimum number of buildings.

While the extent of mica related remediation will vary, it may be conservatively assumed that impacted buildings will be demolished in their entirety. On this basis, the associated waste insulation volumes likely arising due to such remediation are estimated in Table 12 below. Similar to the assumptions used in the case of buildings impacted by pyrite, the estimated waste volumes are conservatively based on the largest dwelling type (detached), 100% of floor slab demolition and up to 100% of wall insulation removal and replacement.

Table 12: Estimated volumes of HBCDD-containing EPS and XPS insulation waste - dwellings impacted by mica (Donegal & Mayo)

Typical Volume of Insulation by House Type		**Dwellings Affected**	**Units Remediated (100%)**	**Waste Insulation Volume (m^3)**	
					Demolition/ Remediation
Detached	Wall (5.1-6.7 m^3)	1,545	1,545	Wall	7,880-10,352
	Floor (8.1-8.9 m^3)			Floor	12,515-13,751
				Total	20,394-24,102
Estimated HBCDD-containing EPS insulation waste (max. 85%)					**17,335-20,487**
Estimated HBCDD-containing XPS insulation waste (max. 10%)					**2,039-2,410**

As noted previously, the above estimates relate to the number of properties likely to be affected by mica based on available statistics published for the counties of Donegal and Mayo. The enhanced remediation scheme enabled by the aforementioned Act 28 of 2022 will extend to additional properties in counties Clare and Mayo.

4. Knowledge Gaps Observed

4.1 Insulation Product Supplier Data (Survey Engagement)

As noted in Section 1.7.2 previously, there were no responses received to the online survey issued to the agreed list of main economic operators. The survey recipients were contacted by means of telephone call and email following the original survey completion date to further understand the lack of engagement. Where contact was successful, a number of common responses were received regarding difficulty in completion of the survey. These are summarised as follows:

- **Business needs** – given the extremely busy nature of the market and resource constraints, businesses were focused on addressing essential business needs and had difficulty in making personnel available for researching the necessary data for responding to the survey. A number of survey recipients queried whether the survey was mandatory or if a specific obligation existed to complete the survey.
- **Historical nature of survey** – since the ban on HBCDD, the main economic operators have switched to alternative products and reliable data on the supply and use of legacy products may no longer be readily available. Personnel engaged in the relevant products or having the appropriate knowledge of the relevant products may no longer be in the same role (or company), in particular for the earlier part of the period of investigation (i.e. 1990s).
- **Difficulty in identifying appropriate personnel within business** – a number of respondents indicated that they were unable to identify the appropriate employee or contact who could supply the relevant data required for a survey response.
- **Commercial sensitivity** – while it was noted that no individual survey returns or individual responses would be identified as part of the consultation and survey, a number of respondents indicated that product data could not be shared on the basis of commercial sensitivity.

A knowledge gap therefore remains in relation to the specific quantification and extent of the use of EPS and XPS insulation containing HBCDD in the Republic of Ireland. However, given the requirements of the Irish Building Regulations (Part L) since 1991/'92 and further to consultation with the NIAI, it is understood that HBCDD-containing EPS insulation products represented approximately 80-85% of the market share between 1990 and 2005/'06 with a subsequent drop in market share to approximately 20-25% up to the ban on HBCDD in 2016. The market demand for XPS insulation products in Ireland is understood to have been significantly lower compared to EPS insulation and the use and quantification of XPS insulation products remains less certain.

The aforementioned University of Birmingham study[44] of 2018 conducted on brominated flame retardants in Irish waste streams included the sampling of EPS and XPS waste streams from (i) recently demolished buildings (ii) a demolition company with stockpiles of reusable insulation and (iii) a construction and demolition waste collection site. The study found that HBCDD was detected in 100% of the EPS samples at concentrations ranging between 0.08 mg/kg and 10,000 mg/kg and in 100% of the XPS samples at concentrations between <0.34 mg/kg and 94 mg/kg. Median concentrations were 100 mg/kg and 19 mg/kg for EPS and XPS respectively. The study highlighted that the median concentrations of HBCDD were substantially lower than that reported at EU level (refer to Section 1.6), raising the possibility that much of the HBCDD originally present may have been released into the surrounding environment during the lifespan of the product.

Data from Members States examined as part of this study would indicate HBCDD concentration varied (again linked to country specific building codes/regulations) and were found in concentrations of 1,000 ppm and higher. As described in Section 1.6, UNEP research has identified the typical concentration range of HBCDD in EPS insulation materials (5,000-10,000 mg/kg) and in XPS insulation materials (8,000-25,000 mg/kg).

[44] Drage et al., 2018. Brominated Flame Retardants in Irish Waste Polymers: Concentrations, legislative compliance, and treatment options.

4.1.1 Limitations – Alternative Methodology

The alternative methodology utilised for the estimation of EPS/XPS insulation material demand during the period of investigation has a number of limitations, which may be summarised as follows:

- While data on the floor area of the building stock is readily available from CSO data, the typical wall area requiring insulation will vary significantly from building-to-building (as further described in Appendix 2).
- Further to consultation with the NIAI, typical thickness values for insulation materials installed in building floors and walls have been assumed in order to estimate expected insulation volumes and associated future waste volumes. It is acknowledged that the thickness of insulation materials will have varied based on different construction/design practices and material specification / product selection.

4.2 Non-Residential Building Sector

In the absence of supply side data, this study focused on estimated quantities by way of investigating the likely quantities of insulation materials required to meet the supply of new residential building stock constructed in Ireland during the period of investigation. While this has resulted in estimated volumes of EPS/XPS insulation materials supplied and associated waste volumes arising for that housing stock, it has not been possible to apply the same methodology for calculating corresponding quantities for the non-residential building sector.

The quantities of HBCDD-containing EPS and XPS insulation products supplied for use in non-residential construction remains a knowledge gap. The National Renovation Strategy of 2020 states that there are an estimated 124,000 buildings in the commercial and public sector in Ireland with the largest numbers being offices and retail outlets. Of these buildings, 15,000 are in use by the public sector (predominantly education, healthcare and office buildings) and 109,000 are commercial buildings (office, retail, restaurant/public house, warehouse, hotel etc.). While data is also available for the period of construction and floor area of these buildings, the wide variety in building design, wall heights and insulation requirements has meant that estimation of insulation quantities is not possible utilising the same methodology employed for the housing stock which is generally more homogeneous in its profile.

4.3 Rate of Demolition & Renovation

As described in Section 1.7.4, the rates of building demolition and renovation activity used to inform projected waste volumes were based on data contained in the National Renovation Strategy (2020) and published estimates for the UK, further to consultation with the NIAI. No public databases or statistics were identified for the number of buildings demolished in Ireland per year. Additional data for demolition / renovation activity may be available by way of further consultation with relevant bodies e.g. CSO, planning authorities, the Construction Industry Federation (CIF) or Irish Association of Demolition Contractors (IADC). This consultation was beyond the scope of the current study and project plan. Such data may be useful in refining the waste volumes of HBCDD-containing EPS/XPS insulation materials likely to arise in future years.

As reported in Section 1.7.4, a UK estimate indicates that <1% of the UK building stock (50,000 buildings) are demolished each year.

While the rate of building renovation has been investigated as part of the National Renovation Strategy, available statistics are largely related to renovations carried out within the framework of State incentives for energy efficiency upgrades. Renovations (especially those of a minor nature) carried out privately may be readily carried out without requiring planning permission or an equivalent record. This results in a knowledge gap on the exact level and extent of building renovations carried out annually, which will in turn impact on the estimated waste volumes likely to arise in future years.

4.4 Period of Investigation

In line with the project brief, the period of investigation for the use of HBCDD in EPS and XPS insulation materials was taken to be 1990 to 2016. Consultation with the NIAI suggests that this period aligns well with the predominant period of market demand for HBCDD-containing EPS and XPS insulation materials (EPS especially). This was driven by the enactment of the Building Control Regulations in 1991 (S.I. No. 306 of 1991), specifically Part L of the First Schedule of the Regulations which introduced the first prescriptive energy efficiency requirements for buildings in Ireland.

The Dutch Ministry of Infrastructure and the Environment previously identified[45] that HBCDD was first used in EPS in the Netherlands from 1975 onwards with a significant increase in 1990. This Dutch study assumed HBCDD in 50% of construction EPS from the period 1975-1990 and in 100% of construction EPS from 1990 to 2015.

In the absence of supply data and survey engagement (Section 3.1.1), there remains some uncertainty regarding the demand and supply of HBCDD-containing EPS and XPS insulation materials prior to the period of investigation i.e. before 1990.

[45] *HBCDD in EPS/XPS waste in the Netherlands. Inventory of size and value.* Ministry of Infrastructure and the Environment (2016)

5. Recommendations

Recommendation No. 1 – Non-Residential Building Stock Demand for EPS and XPS Insulation

As reported in Section 3, estimates calculated for HBCDD-containing EPS and XPS insulation products are limited to the housing stock based on available information and in the absence of supply-side survey data. In order to review the corresponding demand and likely quantities of EPS and XPS insulation materials installed in the non-residential building stock, further data on these buildings (i.e. public sector, commercial/industrial) and their period of construction may be available by means of further consultation with the following:

- CSO
- Office of Public Works (OPW)
- Department of Environment, Climate and Communications (Energy)
- Department of Housing, Local Government and Heritage (Planning)
- Local Authorities (including Local Authorities Members Association)
- CIF.

Recommendation No. 2 – Future Demolition Activity

As part of the current study, limited data was identified relating to the level of demolition activity undertaken annually in Ireland i.e. relating to the number of buildings demolished per year. Detailed waste statistics are available for the total quantity of C&D waste generated each year in Ireland which indicates that mixed waste (likely to be the component of interest), represents 5% of the total C&D waste[46]. However, the number of building units demolished and the number of buildings renovated is not recorded, at least in aggregate terms at a national level. C&D waste quantities are also heavily skewed by stone and soil volumes which are not relevant to the estimation of insulation waste products.

Demolition activity will be highly variable and largely influenced by individual project and development requirements. Notwithstanding the variation likely to occur year-to-year, it is likely that further insight and intelligence may be gained from those bodies having a direct interface with demolition works carried out. Further consultation with the CIF, Irish Association of Demolition Contractors (IADC) and planning authorities may produce additional data to inform historical or current estimates on the number of buildings demolished in Ireland annually and the typical period of construction of buildings demolished. From this data, future trends on likely building demolition activity could be determined supporting further estimation on the volumes of HBCDD-containing EPS and XPS insulation waste.

Recommendation No. 3 – Properties Impacted by Mica & Pyrite

A significant source of building demolition waste in the short, medium and long term will be the remediation of houses impacted by defective building materials, including those dwellings significantly affected by mica and pyrite as reported in Section 3.2.1. Given the current nature, scale and extent of buildings impacted and the likelihood of presence of HBCDD-containing EPS/XPS insulation materials, this may warrant prioritisation or greater focus together with the relevant stakeholders including property owners, building contractors, local authorities and waste management companies.

Consultation with the Department of Housing, Local Government and Heritage and/or the Pyrite Resolution Board may identify further data in relation to the projected number of dwellings likely to be significantly modified or demolished due to defective construction materials.

Furthermore, consultation with the relevant local authorities may yield further information relating to the period of construction of properties impacted by defective materials though available data suggests that properties affected were almost all constructed during the period relating to known supply of HBCDD-containing EPS and XPS insulation materials. It is noted that Regulation 2(3)(g) of the Irish POPs Regulations (Section 1.5.3) identifies local authorities as ‘public authorities concerned’ for the purposes of monitoring and

[46] Construction and Demolition Waste Statistics for Ireland. EPA, October 2022.

enforcement (as appropriate) under the Waste Management Acts 1996 to 2011. Regulation 5 sets out the obligation of 'public authorities concerned' to have regard to the requirements of the EU POPs Regulations (Section 1.5.2) and to co-operate with the EPA, including provision of relevant information and records.

Further consultation may in turn may be of benefit in the further estimation of the associated waste volumes of HBCDD-containing EPS/XPS insulation materials likely to arise in the coming years.

Recommendation No. 4 – Audit of Construction & Demolition Projects

In the absence of supply-side (survey) data for EPS/XPS insulation products in Ireland, further analysis may be undertaken by way of audits of future demolition and renovation projects to further understand and assess the presence and previous use of HBCDD-containing EPS/XPS insulation materials.

These audits could be targeted at a range of likely sources of HBCDD-containing insulation waste, for instance:

- Demolition projects for buildings in a range of categories (residential, commercial, industrial, public sector)
- Renovation projects carried out for the purposes of general building upgrades, extensions and change of use etc.
- Renovation projects carried out for the purposes of energy efficiency, including shallow and deep retrofits
- Remediation project carried out in response to defective building materials (i.e. pyrite, mica)

The audits could be focused for different periods of interest, including before and during the period of investigation (1990-2016).

The scope of these audits may include (i) presence of EPS/XPS insulation and identification of products (where possible) (ii) assessment of typical construction practices and typical quantities of insulation materials removed (iii) quantity / thickness of insulation materials installed (iv) review of current waste management practices, segregation, final treatment and subsequent waste data reporting.

Screening and/or sampling of waste insulation products arising for the presence of HBCDD may also be considered. X-ray fluorescence (XRF) may be used for the detection of HBCDD in materials and hand-held analysers have been developed for this purpose.

The findings of such audits are likely to provide significant insight into the volumes of HBCDD-containing EPS/XPS insulation materials present in the building stock and also further data on the waste volumes arising.

Recommendation No. 5 – Awareness & Guidance: HBCDD Fact-Sheet

It is recommended that a stand-alone fact-sheet is produced to ensure the safe handling and promotion of the phasing out of potentially hazardous EPS/XPS across the construction sector. This is of particular importance, for smaller contractors involved in the renovation of buildings constructed from 1990-2016 and where the potential for mixing of construction and demolition waste is likely. Guidance could include:

- Development of a material inventory identifying any hazardous waste that may be produced in all relevant renovation and demolition projects, performed by a person with documented knowledge and experience.
- The requirement for a material and waste management plan for all relevant renovation and demolition projects (based on the material inventory), documenting how waste generated will be checked for hazardous substances, including HBCDD, and how such waste will be segregated and managed appropriately to ensure HBCDD destruction.
- On large scale projects – the appointment of a person responsible for waste ensuring the implementation of the waste management plan and protocol.

Appendix 1 Housing Data

As described in Section 1.7.3, CSO housing statistics were reviewed to identify the following:

- Number of dwellings by period of construction and building type i.e. detached house, semi-detached house, terrace and apartment.
- Average floor area by period of construction and type of dwelling.

The relevant housing data used as the basis of investigation of the likely demand for insulation materials / material volumes (Section 3.1.3) is recorded in Tables A.1-A.3.

Table A.1: Number of dwellings in Ireland by period of construction (1991-2016)[47]

House Type	Period of Construction			
	1991-2000	2001-2005	2006-2011	2011-2016
Detached	111,618 (47%)	103,994 (39%)	69,646 (41%)	15,264 (28%)
Semi-detached	79,107 (33%)	77,125 (29%)	39,852 (23%)	15,297 (28%)
Terrace	19,021 (8%)	33,883 (13%)	21,032 (12%)	2,744 (5%)
Apartment	27,881 (12%)	49,537 (19%)	39,561 (23%)	20,863 (39%)
Total of known building types	237,627	264,539	170,091	54,168
Not stated	1,097	1,571	1,306	-

For those houses where the type of building type was ‘not stated’, these were redistributed proportionally assuming the same share (%) of known building types (e.g. 47% of the dwellings with building type not stated for the period 1991-2000 are assumed to also be detached). This redistribution is reflected in Table A.2.

Table A.2: Estimated number of dwellings in Ireland by period of construction (1991-2016) including redistribution of unknown house types

House Type	Period of Construction			
	1991-2000	2001-2005	2006-2011	2011-2016
Detached	112,133	104,612	70,181	15,264
Semi-detached	79,472	77,583	40,158	15,297
Terrace	19,109	34,084	21,193	2,744
Apartment	28,010	49,831	39,865	20,863
Total	**238,724**	**266,110**	**171,397**	**54,168**

CSO data compiled for Domestic Building Energy Ratings (2009-2019) records the average floor area for the above house type and period of construction. For this dataset, it is noted that the period of construction is banded differently and outside of the Census cycle, as shown in Table A.3. This reflects the introduction of BER certification from 2009.

[47] Census data 2011, 2016

Table A.3: Average domestic floor area by period of construction and type of dwelling[48]

House Type	Floor Area (m^2) by Period of Construction			
	1994-1999	2000-2004	2005-2014 Note 1	2014-2019
Detached	161	177	202.5	214
Semi-detached	102	104	114	122
Terrace Note 2	84	94	106.5	113.5
Apartment	66	74	82.5	84

Note 1: Average values for 2005-2015 calculated based on CSO values reported for the periods 2005-2009 and 2010-2014, in order to provide a representative value for alignment with Census housing data for the period 2006-2011.

Note 2: Values reported are an average of floor area values reported for end-of-terrace and mid-terrace houses.

[48] Table 11, Statistical Release – Domestic Building Energy Ratings (2009-2019), CSO, 17 April 2019

Appendix 2 Estimation of Insulation Demand

Having previously identified the number of residential buildings constructed during the period of investigation and associated floor areas by building type (Appendix 1), the next step in the study calculations included an assessment of corresponding wall areas requiring insulation.

A range of corresponding wall areas were calculated for each of the main residential building types, allowing for variation in the width and depth of a dwelling (e.g. whether a given building is squarer in form or elongated). This required further consideration of typical external wall lengths and heights as follows.

Wall Height: A typical floor to ceiling (storey) height of 2.4 m was assumed, consistent with the norm for minimum room height which is longstanding in Irish Buildings Regulations and planning guidelines.

Wall Length and Area: At its simplest, a given residential building was first considered as a perfect square whereby the width and depth of a house (and external wall length) are equal in value. Accordingly, the length of an external wall was calculated from the square root of the respective floor area (Table A.3, Appendix 1). Many dwellings will of course be more rectangular in footprint, resulting in changes to the total wall area. To allow for this variation, factors of 1, 1.5 and 2 were applied to the width of a dwelling unit first calculated for a 'square' dwelling, with a corresponding reduction in the overall depth of the dwelling unit. This determined a range of external wall lengths by property type (all related to documented floor areas in Table A.3, Appendix 1), which in turn were then used to calculate a range of representative total external wall areas, taking the product of calculated wall length and typical wall height (2.4 m).

Total External Wall Area: The calculation of total external wall area differs by property type. In the case of a detached dwelling, all four external walls were counted. For a semi-detached house, three external wall areas were calculated (i.e. front, back and external facing sidewall / gable wall). For a terraced house, the front and rear external walls were calculated. For apartments, two perpendicular external wall areas were assumed.

Allowance for Window and Door Openings: For the ranges of total external wall area calculated for each building type, a reduction of 30% was also applied to the total wall area, to allow for window and door openings where no insulation was required. It is acknowledged that window and door coverage will vary significantly between different houses based on design, aspect and layout.

Limitations: It is important to emphasise that any methodology to estimate the total wall area of such a large and varied building stock will have significant limitations. For example, the external wall area of mid-terraced and end-terraced housing will differ. For the purposes of this calculation, no distinction is made between end-terrace and mid-terrace housing. As above, the extent of window and door coverage will also vary significantly and a 30% reduction in total insulated wall area has been applied for all property types.

Based on the above methodology, the estimated typical wall areas requiring insulation, by dwelling type and period of construction, are shown in Table A.4.

Table A.4: Estimated typical insulated wall area by period of construction and type of dwelling

House Type	Typical Insulated Wall Area (m^2) by Period of Construction			
	1994-1999	2000-2004	2005-2014	2014-2019
Detached	85-107	89-112	96-120	98-123
Semi-detached	48-51	49-51	51-54	53-56
Terrace	15-31	16-33	17-35	18-36
Apartment	27-34	29-36	31-38	31-38

The installation of insulation in buildings will have involved a range of products and varying thickness of insulating materials. In order to estimate the typical volumes of insulation installed by dwelling type, a typical thickness value has been assumed further to consultation with the NIAI. For the purposes of the current calculations, a typical value of 60 mm of insulating material has been assumed for wall insulation and similarly a value of 50 mm for floor insulation.

Using these values, the typical volumes of insulation products for floors and walls, categorised by dwelling type and period of construction, are shown in Tables A.5 and A.6.

Table A.5: Estimated typical floor insulation volume by period of construction and type of dwelling

House Type	Typical Floor Insulation Volume (m^3) by Period of Construction			
	1994-1999	2000-2004	2005-2014	2014-2019
Detached	8.1	8.9	10.1	10.7
Semi-detached	5.1	5.2	5.7	6.1
Terrace	4.2	4.7	5.3	5.7
Apartment	3.3	3.7	4.1	4.2

Table A.6: Estimated typical wall insulation volume by period of construction and type of dwelling

House Type	Typical Wall Insulation Volume (m^3) by Period of Construction			
	1994-1999	2000-2004	2005-2014	2014-2019
Detached	5.1-6.4	5.4-6.7	5.7-7.2	5.9-7.4
Semi-detached	2.9-3.1	2.9-3.1	3.0-3.2	3.2-3.3
Terrace	0.9-1.8	1.0-2.0	1.0-2.1	1.1-2.1
Apartment	1.6-2.0	1.7-2.2	1.8-2.3	1.8-2.3

Based on the total number of dwellings identified by period of construction (Table A.2, Appendix 1) and the estimated typical insulation volumes by dwelling type for both floor and wall areas (Tables A.5 and A.6), the estimated demand (likely quantities) of insulation products aggregated for new dwellings constructed in Ireland during the period of investigation is shown in Table A.7.

Table A.7: Estimated insulation demand by volume – new dwellings (1991-2016)

House Type	Area of Application	Estimated Insulation Demand by Volume (m^3)				
		1991-2000	2001-2005	2006-2011	2011-2016	Total 1991-2016
Detached	Wall	573,678-717,097	561,160-701,450	402,672-503,340	90,032-112,540	1,627,541-2,034,427
	Floor	902,673	925,813	710,580	163,325	2,702,390
	Sub-total	**1,476,351-1,619,770**	**1,486,973-1,627,263**	**1,113,252-1,213,920**	**253,357-275,865**	**4,329,932-4,736,817**
Semi-detached	Wall	229,231-242,715	225,965-239,257	122,457-129,660	48,255-51,094	625,908-662,726
	Floor	405,308	403,432	228,901	93,312	1,130,952
	Sub-total	**634,539-648,023**	**629,397-642,689**	**351,357-358,561**	**141,567-144,405**	**1,756,860-1,793,679**
Terrace	Wall	17,654-35,307	33,310-66,620	22,046-44,093	2,947-5,893	75,957-151,914
	Floor	80,257	160,196	112,855	15,572	368,880
	Sub-total	**97,911-115,564**	**193,506-226,816**	**134,902-156,948**	**18,519-21,466**	**444,837-520,794**
Apartment	Wall	45,874-57,343	86,419-108,023	72,997-91,247	38,548-48,186	243,839-304,799
	Floor	92,432	184,375	164,442	87,625	528,874
	Sub-total	**138,307-149,755**	**270,794-292,399**	**237,439-255,689**	**126,173-135,810**	**772,713-833,673**
All dwelling types	Wall	866,437-1,052,463	906,854-1,115,351	620,172-768,399	179,782-217,713	2,573,246-3,153,866
	Floor	1,480,670	1,673,815	1,216,778	359,833	4,731,097
	Total	**2,347,107-2,533,133**	**2,580,670-2,789,167**	**1,836,950-1,985,117**	**539,615-577,546**	**7,304,343-7,884,963**

Appendix 3 Copy of Survey

HBCDD in EPS / XPS Building Insulation Products

General 'How to use'

Complete survey insofar as possible, to enter multiple product records, use the "+" icon

Where section not relevant, please enter n/a where applicable

Where the questions posed do not exactly 'fit' your organisation or situation, please provide relevant detail in final 'Comment' section as required.

Survey Background

Regulation (EU) 2016/293 prohibits the production, placing on the market and use of Hexabromocyclododecane (HBCDD), whether on its own, in preparations or as constituents of articles since 2016.

Hexabromocyclododecane (HBCDD) was commonly used in the manufacture of Expanded Polystyrene (EPS) and Extruded Polystyrene (XPS) insulation materials up until its ban. HBCDD has been found to be persistent in the environment, bioaccumulative and toxic, posing risks to both human health and the aquatic environment.

The Environmental Protection Agency (EPA) has commissioned a study to determine the levels of HBCDD-containing EPS and XPS foams used in building materials within the State between 1990 and 2016. As part of this study, the Agency is contacting relevant organisations who may have been involved in the manufacture or supply of EPS and/or XPS insulation potentially containing HBCDD. The information gathered will be used to generate an estimate of the quantity of HBCDD contaminated construction waste which may be generated within the State over the coming years.

The EPA is the competent authority within the State for the Regulation of POPs and has contracted Sweco Ireland Limited (working with Miltcon Services Limited) to assist in engaging with relevant EPS and XPS manufactures and supplier. The EPA would appreciate your assistance as part of this study.

Further information on Persistent Organic Pollutants can be found at www.pops.ie.

GDPR

We have requested your personal data (your name, work email address, business role & work contact number) for the purposes of inputting the information that you provide for the survey (HBCDD in EPS/XPS building insulation materials) into a database. We may use your personal details to contact you in relation to this survey and for future follow up to obtain additional information on the past use of HBCDD in EPS/XPS. The EPA has ongoing obligations in relation to reporting on the use of POPs and hence will maintain this data for a period of five years to support ongoing reporting and assessment activities.

Sweco and Miltcon Services will process your data on behalf of the EPA. The EPA is the data controller in relation to the personal data that you provide. We process your personal data on the basis of identifying contacts for future follow up in relation to the survey or other related activities.

The EPA has taken the appropriate technical and organisational security measures to protect your personal data from loss, abuse and unauthorised access. The number of employees at EPA, Sweco and Miltcon Services that have access to your personal data is limited. Access to the personal data has only been granted for individuals that need to process the personal data in accordance with the purposes that have been stated above.

You have a number of rights in relation to your personal data under Data Protection legislation, for more information on your data protection rights access EPA's Privacy Policy at www.epa.ie.

HBCDD in EPS / XPS Building Insulation Products

Survey Contact Details

Name:

Email:

Contact number:

Role in Business:

Nature of business:

EPS/XPS Insulation Manufacture/Supply

Was your company/business involved in the manufacture and/or supply of Expanded Polystyrene (EPS) insulation in the Republic of Ireland during the period 1990 - 2016?

Yes

Was your company/business involved in the manufacture and/or supply of Extruded Polystyrene (XPS) insulation in the Republic of Ireland during the period 1990 - 2016?

Yes

EPS Product Details

XPS Product Details

Survey Submission

Any other general comments related to the use of HBCDD in EPS or XPS insulation products / manufacture and supply of such products?

HBCDD in EPS / XPS Building Insulation Products

INTRODUCTORY

1 Survey Contact Details

Name:
Email:
Contact number:
Role in Business:
Nature of business:

SPECIFIC

2 EPS/XPS Insulation Manufacture/Supply

If the respondent answers 'no' to both questions they will be directed to the final submission page.

Was your company/business involved in the manufacture and/or supply of Expanded Polystyrene (EPS) insulation in the Republic of Ireland during the period 1990 - 2016?

Was your company/business involved in the manufacture and/or supply of Extruded Polystyrene (XPS) insulation in the Republic of Ireland during the period 1990 - 2016?

3 EPS Product Details

To be completed for each product. Respondent will have facility to add additional lines (one per product)

Please enter brand/product name of Expanded Polystyrene (EPS). Add lines if required. +

Did this product contain HBCDD? (Yes/No/Unknown)

4 Presence of HBCDD - EPS

To be completed for each product selected as 'Yes' or 'Unknown' for HBCDD content in Section 3.

Years engaged in manufacture/supply of this product (select relevant activity and enter years in textbox. Add lines if required):

Please specify the year when use of HBCDD in this product ceased (or final year of product manufacture if product discontinued):

Please upload relevant material safety data sheet (MSDS or SDS) in the field below. In the absence of an SDS, please upload any available supporting information relevant to the composition of the product, including HBCDD content.

5 EPS Product Quantities

To be completed for each product selected as 'Yes' or 'Unknown' for HBCDD content in Section 3.

Total average annual volume (in tonnes) of this EPS insulation product containing HBCDD manufactured in or supplied to the Republic of Ireland: tonne(s)

Please use this section to describe any significant variation that may have occurred in production/supply during the period 1990-2016

If available, indicate (in % or other unit) the HBCDD content for this product. +

Please select typical end users/sectors for the relevant products manufactured/supplied, and enter percentage of business for each sector: % +

Any additional comments on the use/distribution of HBCDD-containing EPS:

6 XPS Product Details

To be completed for each product. Respondent will have facility to add additional lines (one per product)

Please enter brand/product name of Extruded Polystyrene (XPS). Add lines if required. +

Did this product contain HBCDD? (Yes/No/Unknown)

7 Presence of HBCDD - XPS

To be completed for each product selected as 'Yes' or 'Unknown' for HBCDD content in Section 6.

Years engaged in manufacture/supply of this product (select relevant activity and enter years in textbox. Add lines if required): +

Please specify the year when use of HBCDD in this product ceased (or final year of product manufacture if product discontinued):

Please upload relevant material safety data sheet (MSDS or SDS) in the field below. In the absence of an SDS, please upload any available supporting information relevant to the composition of the product, including HBCDD content.

8 XPS Product Quantities

To be completed for each product selected as 'Yes' or 'Unknown' for HBCDD content in Section 6.

Total average annual volume (in tonnes) of this XPS insulation product containing HBCDD manufactured in or supplied to the Republic of Ireland: tonne(s)

Please use this section to describe any significant variation that may have occurred in production/supply during the period 1990-2016

If available, indicate (in % or other unit) the HBCDD content for this product. +

Please select typical end users/sectors for the relevant products manufactured/supplied, and enter percentage of business for each sector: % +

Any additional comments on the use/distribution of HBCDD-containing XPS:

Submission

9 Submit Survey

Any other general comments related to the use of HBCDD in EPS or XPS insulation products / manufacture and supply of such products?

SAVE SURVEY SUBMIT SURVEY