



**CONVERSIO**

Market & Strategy

## Final Report

Waste generation, waste streams and recycling potentials of HBCD-containing EPS/XPS waste in Europe and forecast model up to 2050

Elaborated for

**BASF SE**

Carl-Bosch-Str. 38  
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**BASF**  
We create chemistry

## About Conversio

**Conversio employees are** specialised in B2B research and consultancy and work more than 20 years in the field of plastic production, processing and waste management. They have been assigned by BASF with the survey (development of concept, realisation of the research, analysis and reporting) in October 2019.



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## Initial situation

### HBCD-containing EPS/XPS insulation material

EPS/XPS accounts for about 35-40% of the total thermal insulation market in Europe, with over 50,000 employees in the EPS/XPS industry. For flame retardant reasons the chemical hexabromocyclododecane (**HBCD**) was used in EPS/XPS insulation material since 1980<sup>1)2)</sup>. **Since 2016, products containing HBCD in concentrations of more than 100 mg/kg may no longer be produced or placed on the market in the EU.** The ban on trade and use of HBCD goes back to the Stockholm Convention and is implemented in the European Union (EU) through Annex I to the POPs Regulation (EC) No 850/2004 on persistent organic pollutants (POPs). The regulation requires that waste POPs, like HBCD, must be disposed of or recovered in such a way as to ensure that “the persistent organic pollutant content is destroyed or irreversibly transformed”.

### Management of HBCD-containing EPS/XPS waste

In the management of wastes containing HBCD, the **required destruction is currently achieved through thermal incineration or energy recovery. In the future, mechanical recycling of HBCD containing insulation material will be allowable if its HBCD content is below the limit value of 100 mg/kg** listed in Annex I to the POPs Regulation. Methods to selectively extract pollutants and HBCD from polystyrene material are currently being tested.

<sup>1)</sup>figures based on BASF data <sup>2)</sup>Additional information: (H)CFC was used in XPS insulation material until 2002.

## Initial situation

### PolyStyreneLoop (PSLoop)

**The PolyStyreneLoop (PSLoop) is building the first innovative demonstration plant** based on a process, developed by Fraunhofer and CreaCycle, that separate HBCD from EPS/XPS by dissolving the waste.

**In order to identify the quantitative basis, Conversio will analyse the EPS/XPS waste quantities** collected in 2018, as well as the disposal and recovery possibilities (energy recovery, recycling) for selected countries. **A forecast analysis up to 2050** will be the **focus of the study** regarding feeding the pilot plant for recycling of insulating materials containing HBCD in future.

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# Introduction

## General objective of the study:

Based on identified EPS/XPS waste quantities and disposal possibilities, a future plannability for the utilisation of the pilot plant shall be guaranteed.

## Major targets:

1. Analysis of HBCD-containing and HBCD-free EPS/XPS post-consumer waste quantities from the construction sector (installation and demolition quantities) in Europe and the selected countries.
2. Subdivision of EPS/XPS post-consumer waste quantities into recycling or energy recovery options and landfill in 2018.
3. EPS/XPS post-consumer waste quantities in different waste streams (e.g. residual waste, recycling center) including information on waste quantities containing HBCD.
4. Overview of collecting and recovery options for different applications.
5. Forecast model about EPS/XPS construction waste containing HBCD by 2050.

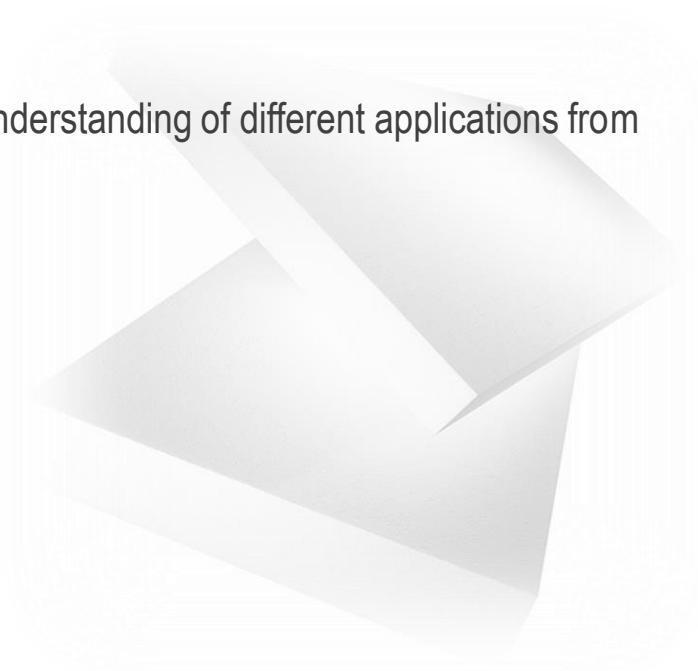
# Introduction

## Construction

Regarding various lifetimes of insulation in buildings, it is necessary to get an understanding of different applications from demolition and construction waste.

EPS/XPS insulation material is often used for

- Roof insulation
- ETICS
- Perimeter insulation
- Floor and ceiling (e.g. footstep sound insulation)
- Other component parts (e.g. interior, door panel)





# Methodology

## Process

### I Pre-analysis

Detailed analysis of the commercial and household waste flows collected at various levels (country, region, city, etc.) in the construction sector.

### II Analysis 1

Interviews, analysis and evaluation of important systems, waste disposal companies, sorting plants, SRF/RDF and MSWI plants, plastic recyclers etc. in the individual countries

### III Analysis 2

Official statistics on country and European level, interviews with market experts, political groups e.g. environmental agencies, associations, construction & demolition companies etc.

### IV Additional Analysis

Additional secondary statistics (e.g. demand data), reports and expert interviews.

## Primary research (in-depth interviews in countries)

- Associations (also Plastic Associations)
- Ministries and Institutions
- EPR Schemes / Actors (e.g. national packaging and non packaging organisations, national plastic recovery organisations)
- Construction & demolition companies, waste management companies, operators of sorting plants, operators of SRF/RDF and MSWI plants, recyclers
- Other market experts

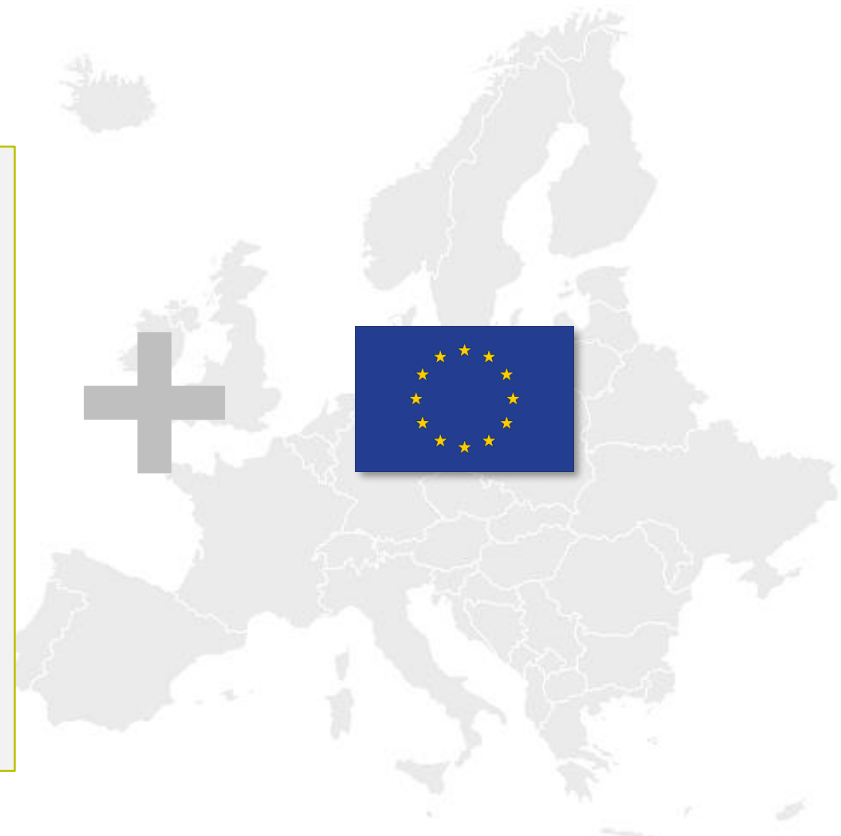
## Secondary Research

- Analysis of existing documentation in Europe (EEA etc.)
- Internet research
- Publications of the Statistical Offices, Federal Ministries, Environmental Protection Agencies and Environment Institutes
- Detailed measurement and analysis of plastic waste in the waste streams of household, commerce and industry.
- Publications in professional journals
- Annual reports of schemes / systems / actors
- Information based on data from federal agencies
- Analysis of available Converso documentation

# Methodology - countries

11 selected countries + Europe

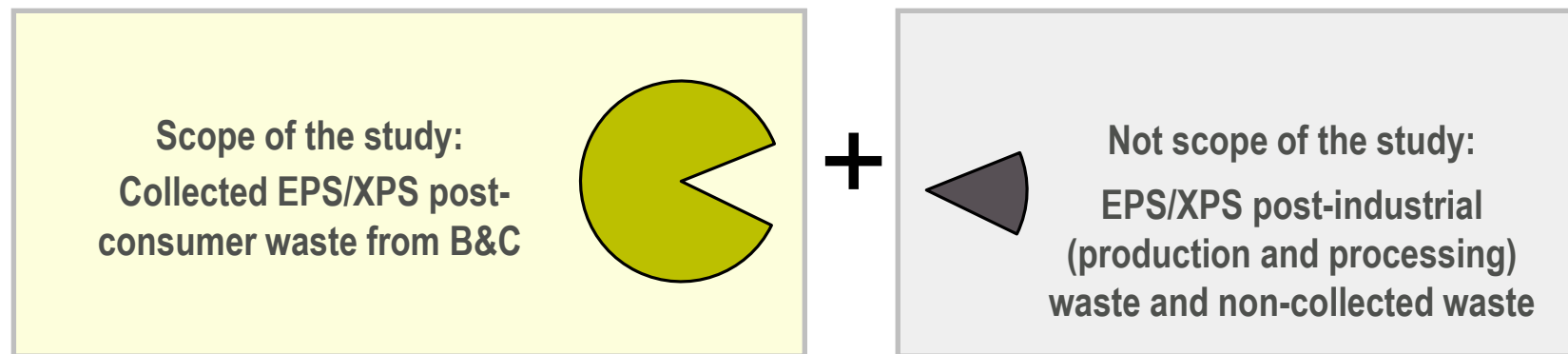
• Austria		• Netherlands	
• Czechia		• Poland	
• Belgium		• Sweden	
• France		• Switzerland	
• Germany		• UK	
• Italy			



## Methodology – definitions 1/3

### *Total collection of EPS/XPS building & construction waste*

Scope of the study: Post-consumer EPS/XPS building & construction waste collected from households, industry and commerce



### Scope of the study

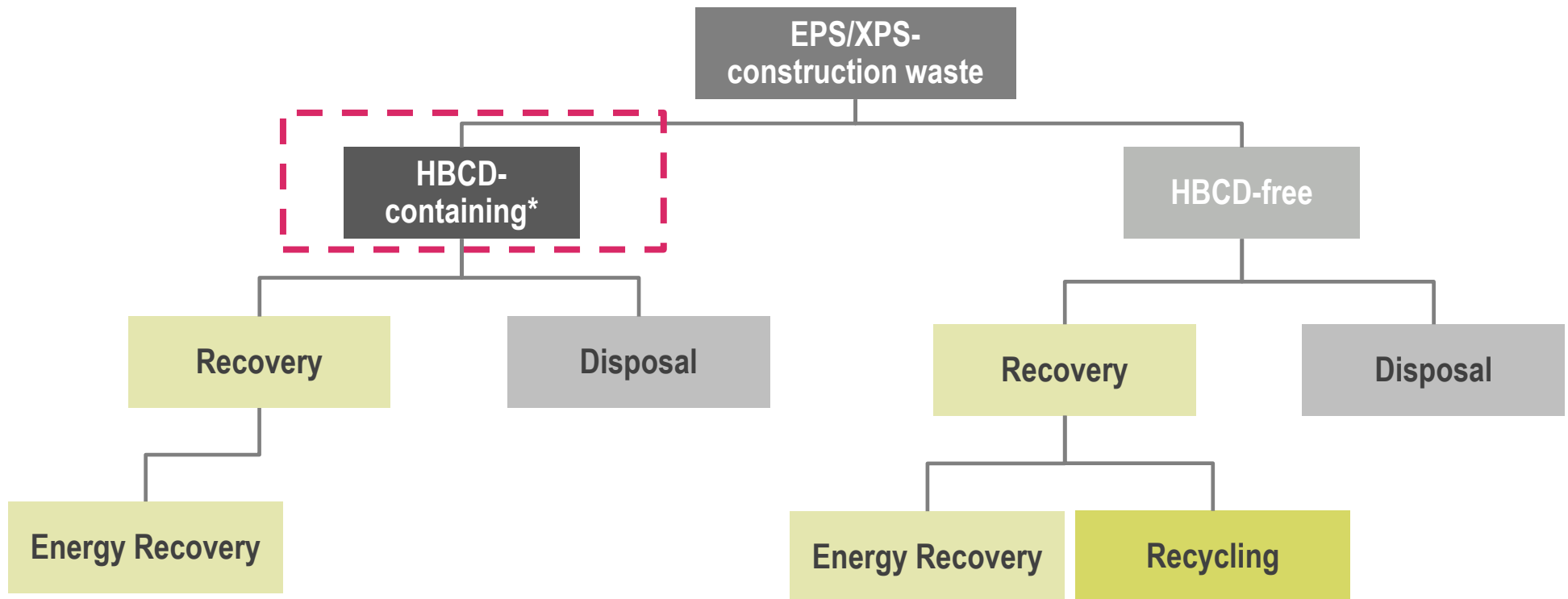
EPS/XPS post-consumer waste is subdivided into waste streams from private households and municipal waste collected by commercial activities, as well as post-consumer waste collected by economic activities, such as manufacturing industry, construction etc.

### Not scope of the study

- Production and processing EPS plastic waste
- Non-collected EPS waste:
  - Littering on land and the marine environment
  - Unauthorized dumping (e.g. roadside-dumping and illegal storage)

## Methodology – definitions 2/3

### EPS/XPS waste quantities and treatment by differentiation in HBCD-containing and HBCD-free construction waste 2018



\*only a proportion of the total HBCD-containing waste material is collected separately and therefore available for PSLoop, detailed explanation see page 28

# Methodology – definitions 3/3

## Relevant EPS/XPS construction waste streams

<b>Residual household waste</b>	Disposal of residual waste from households (residual waste bin) via municipalities; mixed household waste including EPS/XPS construction waste	
<b>Construction waste in household LWP collection</b>	Construction waste (installation waste) is collected separately from mixed household waste/household sector under the financial or operational responsibility of EPR organizations such as "DSD"; EPS installation waste is dropped in LWP by mistake)	
<b>Municipal waste generated by commercial activities</b>	Mixed municipal waste (including EPS/XPS construction waste) similar to household waste and collected on behalf of municipalities.	
<b>Commercial and industrial waste (EPS in mixed construction waste) by private companies</b>	Commercial and industrial waste collected, sorted, disposed and treated by private waste management companies; mainly EPS/XPS demolition waste	
<b>Other collecting and recycling systems / activities for EPS/XPS construction waste</b>	Possibility of return from EPS/XPS manufacturers (e.g. insulation material manufacturers)	
<b>Collecting points / Recycling center</b>	Collection of EPS/XPS construction waste via public and private collection stations	

\*EPS/XPS containing HBCD waste is mainly collected separately in those streams and therefore available for PSLoop, detailed explanation see page 28

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# European summary - About 142kt EPS/XPS construction waste were collected in EU28+2 countries 2018

EU 28+2 2018 EPS/XPS construction waste	Waste collected in kt				Recovery in kt				Disposal in kt
	EPS in kt	XPS in kt	Total	%	Mechanical Recycling as EPS/XPS	Mechanical Recycling as PS	Energy Recovery	Total	Total
Installation waste (no HBCD)	26.8	5.4	<b>32.2</b>	23%	10.2	2.4	9.6	<b>22.2</b>	<b>10.0</b>
Demolition waste (no HBCD & HBCD containing)	94.8	14.7	<b>109.5</b>	77%	1.0	0.3	85.1	<b>86.4</b>	<b>23.1</b>
<b>Total Construction Waste</b>	<b>121.6</b>	<b>20.1</b>	<b>141.7</b>	<b>100%</b>	<b>11.2</b>	<b>2.7</b>	<b>94.7</b>	<b>108.6</b>	<b>33.1</b>
					8%	2%	67%	77%	23%

- Compared to previous year<sup>2)</sup> the total amount of EPS/XPS collected construction waste increased by 2.2% to ca. 142kt in 2018, because of growing construction activities, positive economical situation and a raising demand of EPS. The European share of XPS was approx. 14% in 2018.
- Because of cleaner conditions EPS/XPS installation waste was primarily recycled in the past. In 2018 ca. 13.9kt were recycled (10%) while ca. 95kt (67%) were energy recovered and 33kt (23%) disposed.
- Reasons for lower recycling quotas of EPS/XPS demolition waste, are the bad quality of EPS/XPS materials from demolition (high impurities, contamination, etc.) and the lack of separate collection. Mixed demolition waste is mainly energy recovered (~85kt) or send to landfill (~23kt).

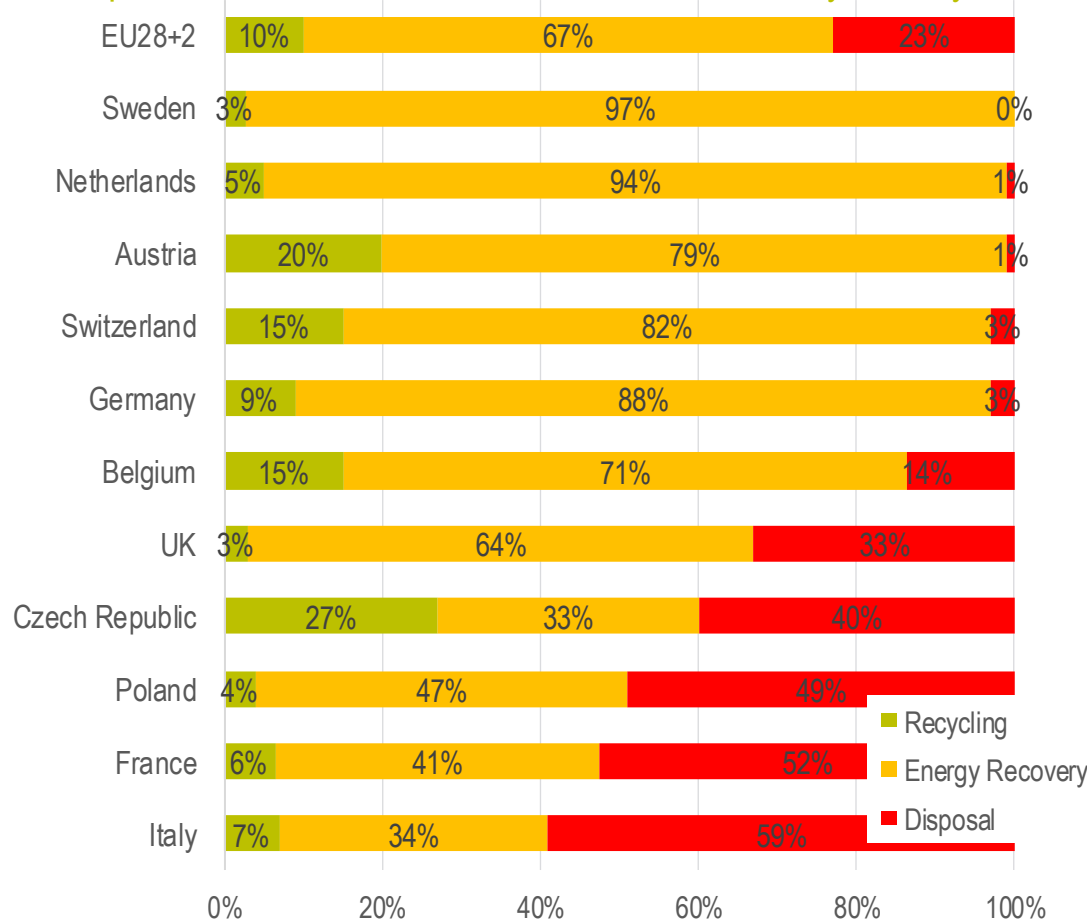
<sup>1)</sup> Total construction waste amount includes only post-consumer waste quantities - no post-industrial waste quantities (definition according to slide 10)

<sup>2)</sup> Reference to 2017 figures of European EPS waste study (EUMEPS) generated by Conversio in 2018 ; in this study XPS is included in the EPS waste amount (EU:~139 kt of EPS/XPS)



# European summary – 10% of EPS/XPS construction waste was mechanically recycled in Europe 2018

## Total post-consumer EPS/XPS construction waste by country and treatment in 2018



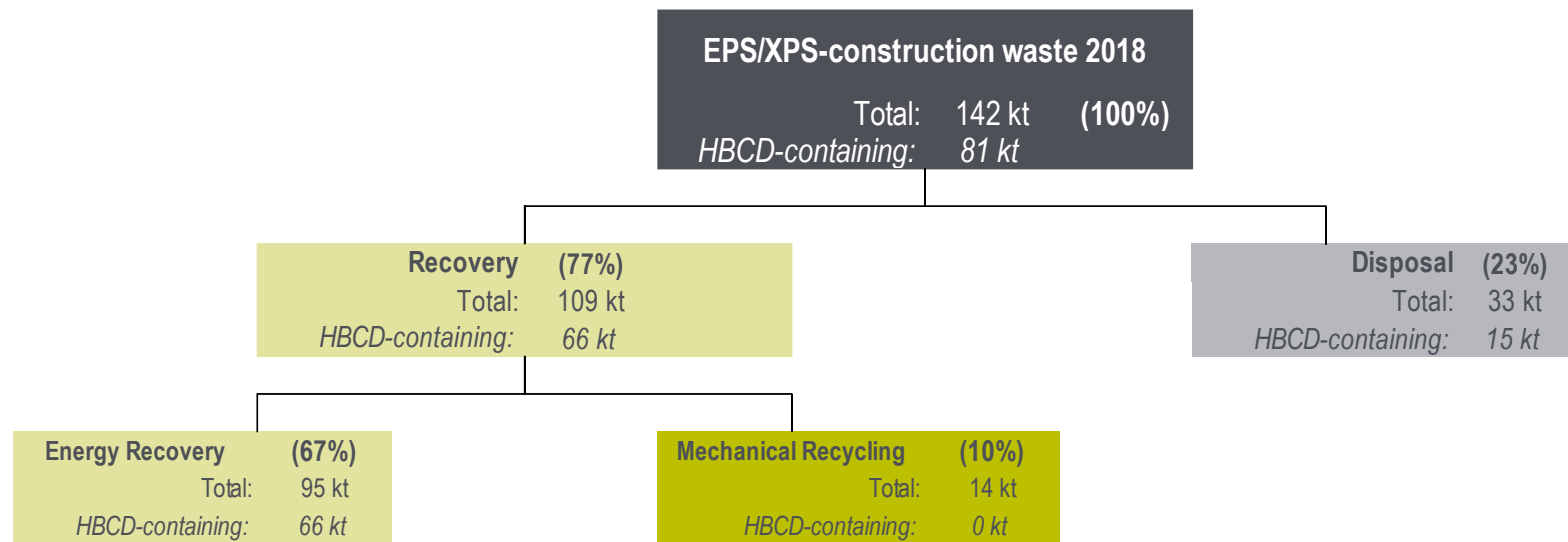
- In 2018 EPS/XPS construction waste recovery accounted for almost 77% including 10% recycling and 67% energy recovery. Still about 23% of post-consumer EPS/XPS construction waste was disposed.
- With the implementation of landfill bans, 5 out of 11 selected EU28+2 countries had recovery rates over 96%.
- Larger European countries such as the UK, Poland, France and Italy had high disposal rates between ~30% and ~60% in 2018.
- With an EPS/XPS construction recycling rate of around 27% Czech Republic is one of the leading recycling countries in Europe.





# European summary – In 2018 67% of EPS/XPS waste was energy recovered and still 23% was disposed

## EPS/XPS HBCD-free and HBCD-containing construction waste in 2018

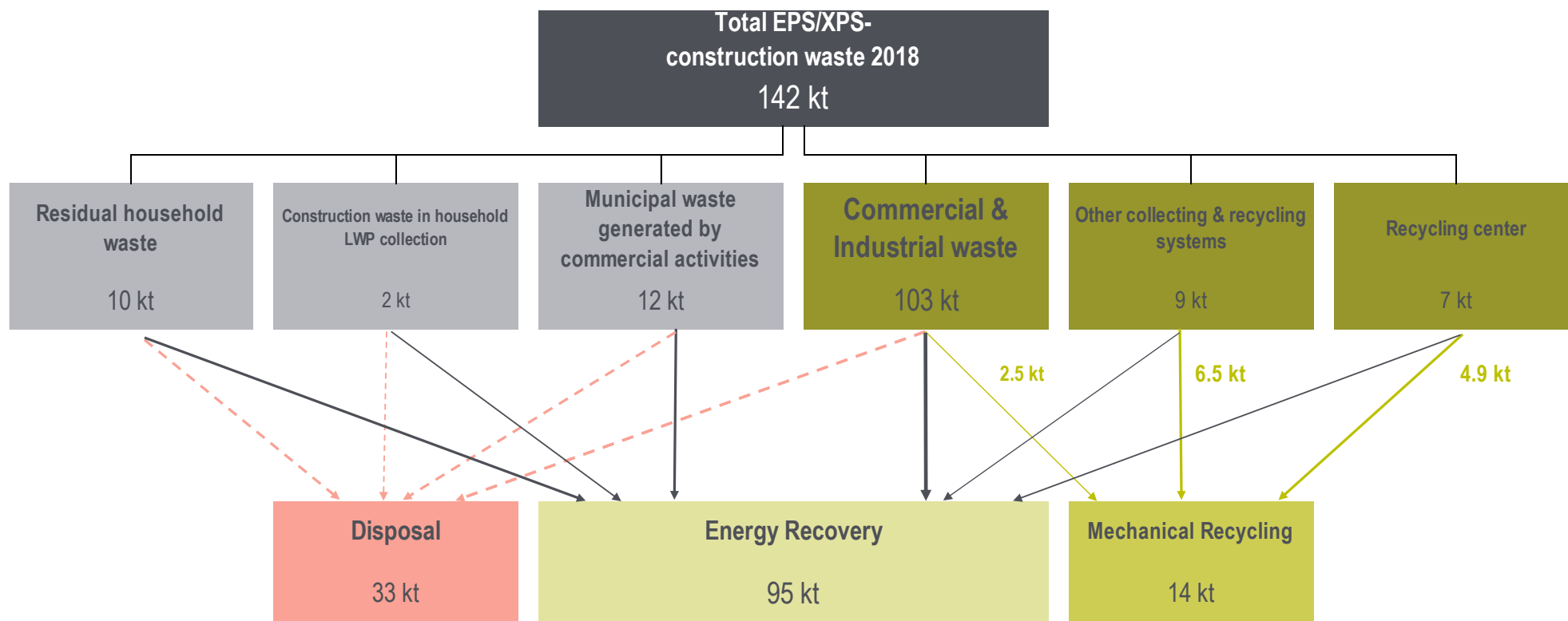


- In 2018 around 142kt of EPS/XPS construction waste was collected. Due to a lack of separate collection systems in many European countries, still 45kt (32%) EPS/XPS construction waste was sent to disposal.
- In Europe ca. 81kt (~57%) of the EPS/XPS construction waste contained HBCD (especially demolition waste). Thereof approx. 66kt were recovered and 15kt disposed. Only 26kt of the total HBCD-containing waste material is collected separately and therefore available for PSLoop.
- In 2018 only HBCD-free EPS/XPS construction waste was mechanically recycled (~14kt). This amount results mainly from separate collected waste streams like e.g. recycling center, return systems.



# European summary – Approx. 73% of EPS/XPS waste was collected in Commercial & Industrial stream

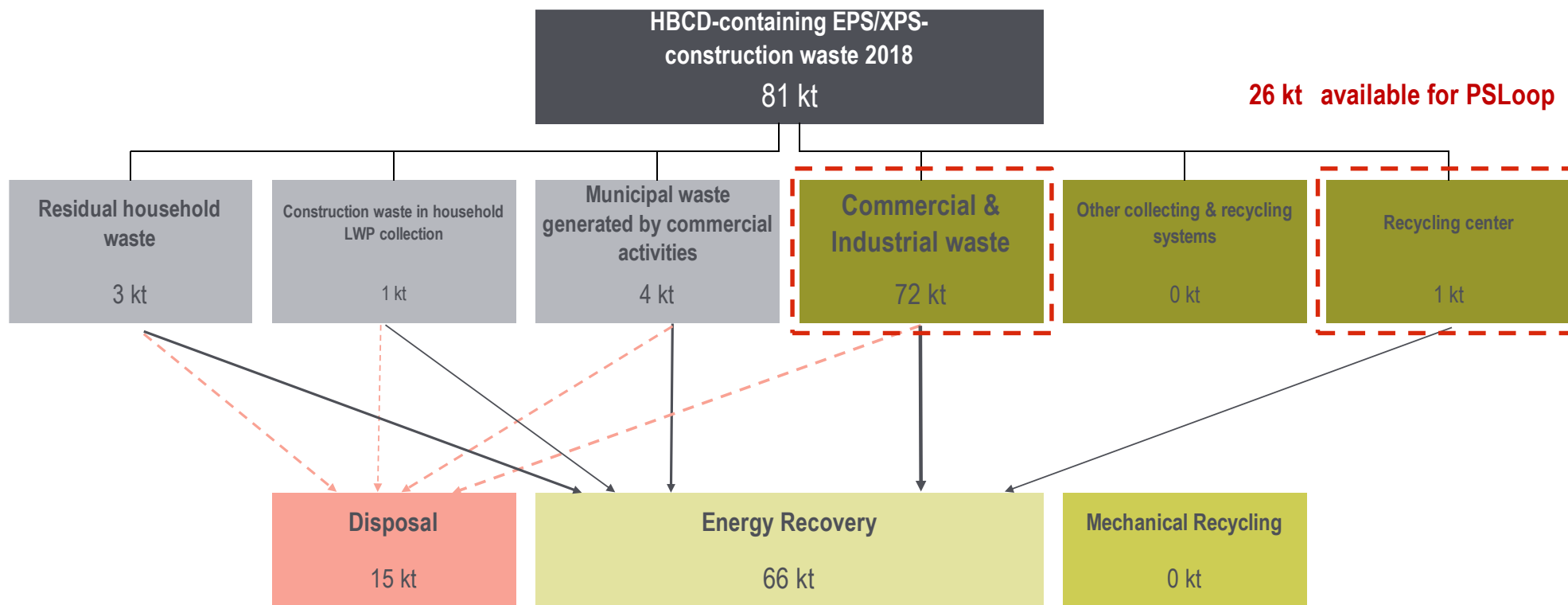
Total EPS/XPS (no HBCD & HBCD-containing) construction waste streams in 2018





# European summary – High availability of HBCD-containing EPS/XPS waste for PSLoop in two streams

## EPS/XPS HBCD-containing construction waste streams in 2018



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# Germany – About 48kt of EPS/XPS construction waste was collected in 2018

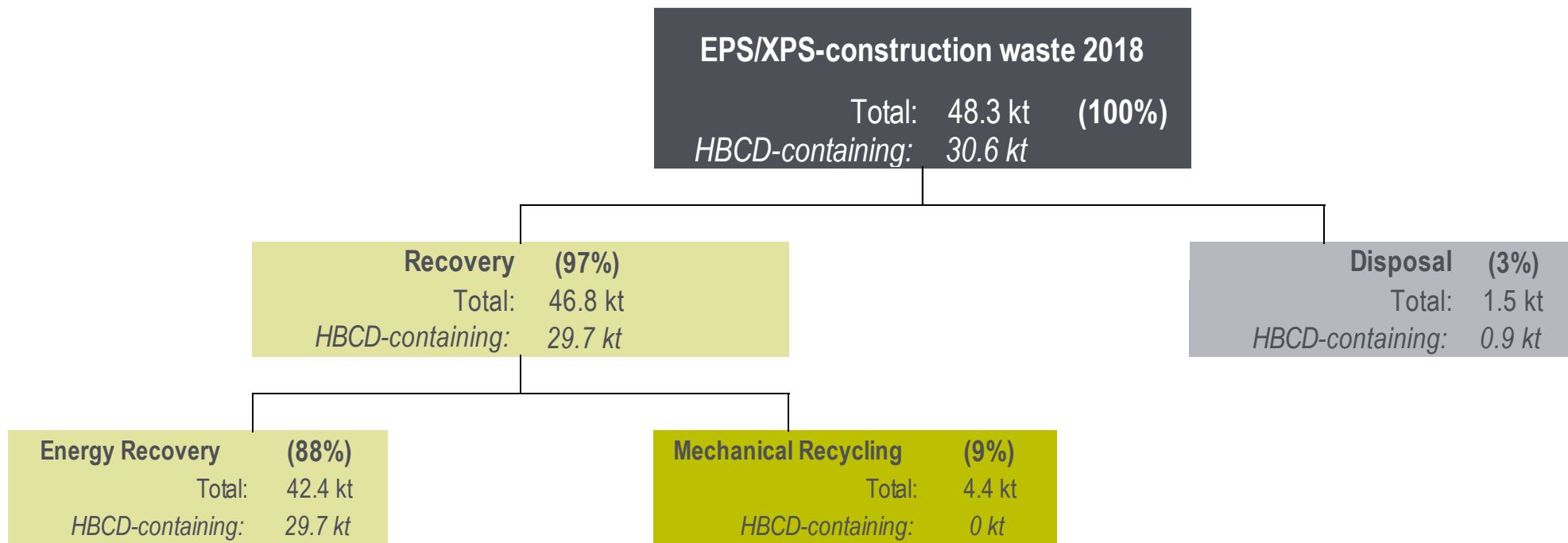
Germany 2018 EPS/XPS construction waste	Waste collected in kt				Recovery in kt				Disposal in kt
	EPS in kt	XPS in kt	Total	%	Mechanical Recycling as EPS/XPS	Mechanical Recycling as PS	Energy Recovery	Total	Total
Installation waste (no HBCD)	6.0	1.2	7.2	15%	3.3	0.5	3.0	6.8	0.4
Demolition waste (no HBCD & HBCD containing)	38.2	2.9	41.1	85%	0.5	0.1	39.4	40.0	1.1
<b>Total Construction Waste</b>	<b>44.2</b>	<b>4.1</b>	<b>48.3</b>	<b>100%</b>	<b>3.8</b>	<b>0.6</b>	<b>42.4</b>	<b>46.8</b>	<b>1.5</b>
					8%	1%	88%	97%	3%

- Positive development in the housing sector in 2018 and 2019 with about 5 to 10% growth (about 105,000 completed residential units) compared to the last year's figures (2017).
- Apartment building, on the other hand, is currently in a downturn but for 2020 an upward trend is expected.
- The nominal construction volume will grow by 15% between 2018 and 2020. The renovation measures are not pushed back as initially assumed but continue to grow with a trend towards energy efficiency.
- Approx. 70% of EPS are used for roof insulation and facade insulation boards. The rest is used for perimeter, floor and ceiling insulation.
- Most of the recycled EPS came from installation waste. The waste is often grinded and used for fills in the production of briquettes. Only a little volume is recycled as PS (~1%).



Germany –  
Most of EPS/XPS waste was recovered (97%); 9% was mechanically recycled

EPS/XPS HBCD-free and HBCD-containing construction waste in 2018

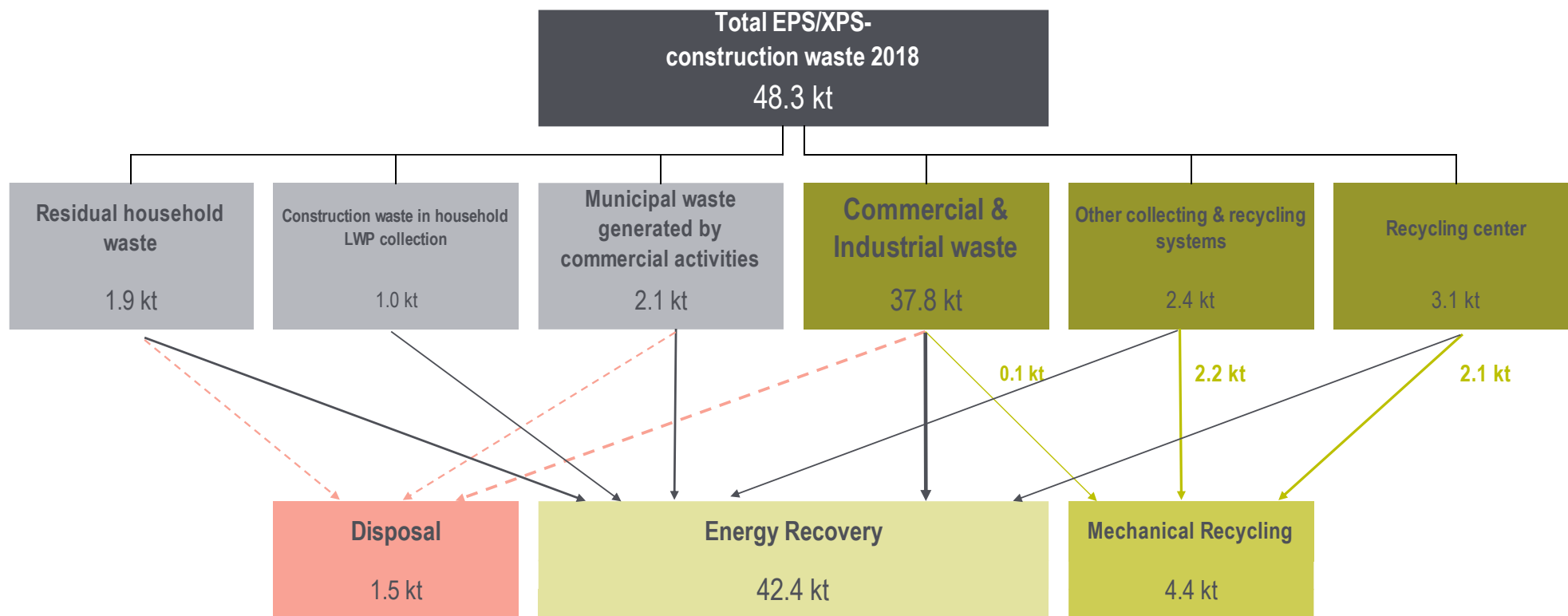


- About 63% of the EPS/XPS construction waste contains HBCD.
- Approx. 74% of the demolition waste (41.1kt) contains HBCD.
- Ca. 9% (4.4kt) of the EPS/XPS was recycled (only HBCD-free material)

# Germany – Approx. 79% of EPS/XPS waste was collected in Commercial & Industrial waste stream



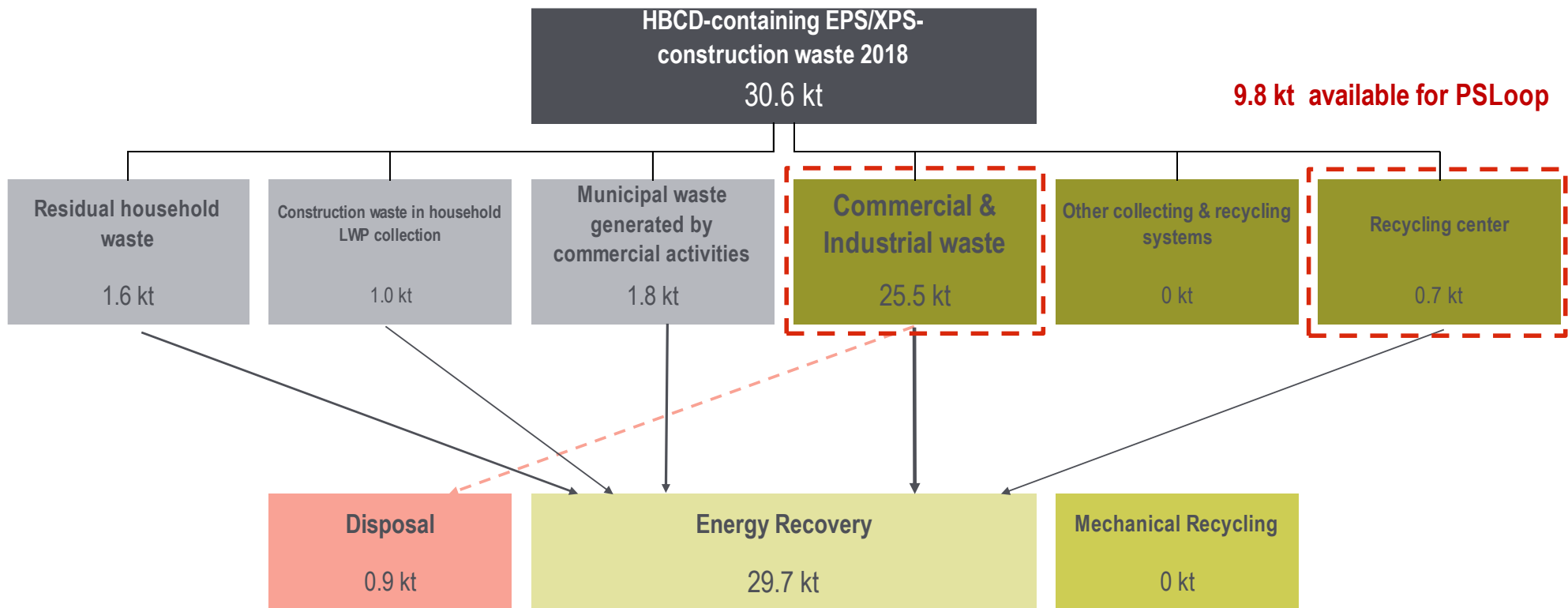
Total EPS/XPS (no HBCD & HBCD-containing) construction waste streams in 2018





# Germany – An available amount of 10kt HBCD-containing EPS/XPS waste can be assumed

## EPS/XPS HBCD-containing construction waste streams in 2018




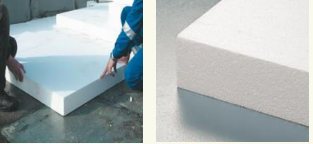




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# European overview of collecting and recovery options 2018

Applications	Quality <sup>1)</sup> (reinforcement , adhesive etc.)	Waste Management (mixed vs. separate collection)	Treatment <sup>2)</sup> (Recycling, energy recovery, disposal)
<p>ETICS</p> 	<p>Waste with <b>high impurities</b>: wall plaster, adhesive, possibly dowels, mortar, reinforcement grid (EPS share only ca. 10 weight %)</p>	<p><b>Demolition</b> waste is mainly collected in <b>mixed</b> construction and partly in separated streams (referred to waste code 170604 also other insulation materials could be included).</p>	<p>Partly into the crusher (separation EPS/XPS via wind separator); <b>low recycling of “EPS in composites”</b></p>
<p>Flat roof &amp; floor insulation</p> 	<p>Waste with <b>low impurities</b>: XPS/ EPS insulation boards usually laid in form of loose panels (without other fixing element) (EPS share ca. 90 weight %)</p>	<p>In some European countries EPS/XPS <b>installation waste</b> is collected <b>separately</b> (e.g. in EPS big bags).</p>	<p><b>Only clean EPS material</b>, especially installation and demolition waste of flat roofs with PVC membranes. EPS, which is not polluted, e.g. without bitumen, can be recycled.</p>
<p>Perimeter insulation &amp; Others</p>  	<p>Waste with <b>high impurities</b>: XPS panels with adhesives / anchors on a moisture-proof coating; wall plaster and reinforcement grid on top or dense plastic drainage mats under the floor</p>	<p>In some European countries EPS/XPS <b>installation waste</b> is collected <b>separately</b> (e.g. in EPS big bags).</p>	<p><b>Difficult demolition</b> of perimeter insulation; material is mainly energetically recovered because of high impurities</p>

- 1) The impurities of EPS/XPS differs depending on the installation and removal procedure. While ETICS are usually installed by anchors and adhesives, the flat roof insulation panels be fastened in various ways. Dependent on the construction EPS/XPS panels can be removed in different ways: sawing, breaking, manual removal, milling, peeling with an excavator etc.
- 2) Pre-cleaning and compaction by manual sorting, air separation, washing, wet separation and pressing

Source: STREC, EPS/XPS Recycling Baubereich, 2016; PolystyreneLoop, Guideline on the Collection and Pre-treatment of polysterene foams for PolyStyrene Loop, 2019

## Forecast model (1/7)

### General Overview: Forecast model of HBCD-containing EPS/XPS construction waste

For the estimation of the forecast model different **sources and parameters** were considered.

- Historical production and consumption data of EPS and XPS:
  - Internal BASF data / manufacturer's production figures
  - Own historical calculations/ data from giraf results
  - PEMRG data
- "Life Span" of the different EPS / XPS applications (e.g. ETICS; Perimeter, Roofing etc.)
  - Existing estimates from secondary literature (lifetime analysis)
  - Estimations from market experts (e.g. roofing federations)
- Annual decommissioning / refurbishment amounts
  - Existing estimates from secondary literature
  - Discussions with processors, demolition companies and associations
  - Own calculations, comparison with the amounts of waste accumulated in recent years
- Forecast model based on a stable economic development without political measures in the construction sector

# Forecast model (2/7) – Assumption of available HBCD-containing EPS/XPS waste quantities for PS Loop

## Forecast of **available** HBCD-containing EPS/XPS construction waste quantities

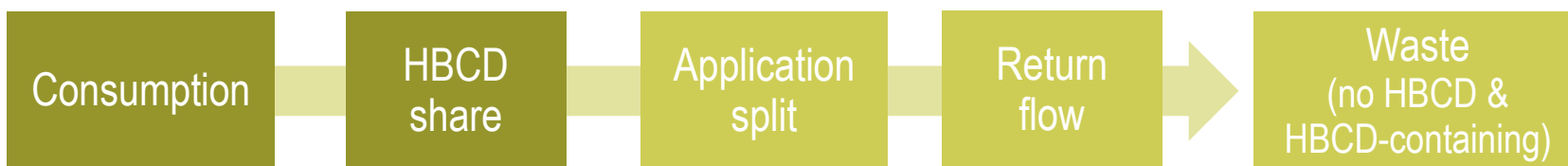
Because of increasing legal restrictions and environmental awareness a significant amount of HBCD-containing EPS/XPS construction waste (incl. others like PUR, mineral wool etc.) was **already collected separately** at recycling centres or directly on construction sites. These **separate collected HBCD-containing EPS/XPS amounts** will be cost-effective\* available for the PSLoop plant (without considering further technical specifications and material requisition).

	Recycling center	Commercial and industrial waste
<b>Separate collection of EPS/XPS HBCD-containing waste</b>	HBCD containing EPS/XPS insulation waste from demolition is collected separately at recycling center (including others such as PUR, mineral wool, etc.). This <b>separate collected material</b> is cost-effective available for further processes (PSLoop).	Only some amounts of HBCD-containing EPS/XPS demolition waste is collected separately on construction site and will be therefore available. Regarding appropriate regulations, HBCD-containing EPS/XPS demolition waste has to be collected on construction site as mono fraction in separate containers (including others such as PUR, mineral wool, etc.). But e.g. smaller EPS/XPS waste or contaminated waste amounts can also be collected in mixed construction waste containers. The <b>partly separate collected HBCD containing</b> amounts on construction site are a profitable source for feeding the PSLoop plants.
<b>Assumptions</b>	Energy recovery and disposal amounts are assumed as HBCD-containing EPS/XPS waste; mech. recycling quantities are HBCD-free	Energy recovery and disposal amounts are assumed as HBCD-containing EPS/XPS waste; mech. recycling quantities are HBCD-free. Based on expert interviews can be assumed that large amounts of HBCD-containing material are collected separately.

\*pre-treatment of other waste streams e.g. residual household waste, LVP collection etc. is not economically reasonable because of low penetrations and technical complexity

# Forecast model (3/7)

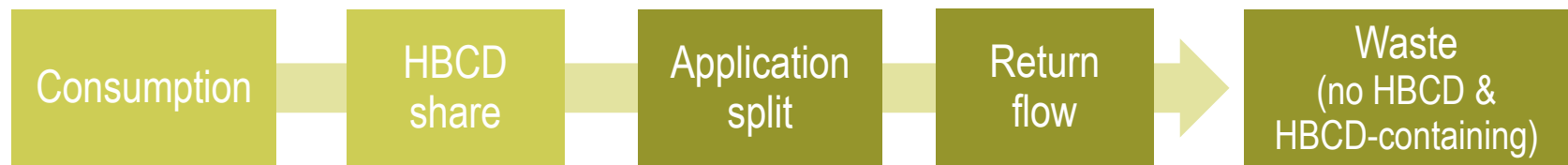
## Forecast model of HBCD-containing EPS/XPS construction waste (1/2)



Variables	Consumption	HBCD-share																																																		
Assumptions / Criteria	<p>Basis figure for calculation is the consumption data of total EPS/XPS for B&amp;C. Historical consumption data of EPS and est. share of XPS <b>until 2018</b> e.g. EPS and XPS consumption in Germany:</p> <table border="1"> <thead> <tr> <th>Year</th> <th>EPS Consumption</th> <th>Year</th> <th>XPS Consumption</th> </tr> </thead> <tbody> <tr> <td>1955</td> <td>5.082 t</td> <td>1965</td> <td>77 t</td> </tr> <tr> <td>1956</td> <td>6.352 t</td> <td>1966</td> <td>97 t</td> </tr> <tr> <td>1957</td> <td>7.940 t</td> <td>1967</td> <td>121 t</td> </tr> <tr> <td>...</td> <td>...</td> <td>...</td> <td>...</td> </tr> </tbody> </table> <p>If no valid data were available, consumption figures were adapted by GDP, construction activity and/or demand (see p. 93-94)</p>	Year	EPS Consumption	Year	XPS Consumption	1955	5.082 t	1965	77 t	1956	6.352 t	1966	97 t	1957	7.940 t	1967	121 t	...	...	...	...	<p>HBCD-share is depending on the year of HBCD usage in EPS and XPS construction material e.g. HBCD-containing EPS in Germany:</p> <table border="1"> <thead> <tr> <th>Period</th> <th>HBCD</th> <th>HBCD-free</th> <th>Period</th> <th>HBCD</th> <th>HBCD-free</th> </tr> </thead> <tbody> <tr> <td>1955-1979:</td> <td>0%</td> <td>100%</td> <td>2002-2014:</td> <td>95%</td> <td>5%</td> </tr> <tr> <td>1980-1985:</td> <td>75%</td> <td>25%</td> <td>2015:</td> <td>75%</td> <td>25%</td> </tr> <tr> <td>1986-1990:</td> <td>85%</td> <td>15%</td> <td>2016:</td> <td>50%</td> <td>50%</td> </tr> <tr> <td>1995-2001:</td> <td>90%</td> <td>10%</td> <td>2017-2050:</td> <td>0%</td> <td>100%</td> </tr> </tbody> </table> <p>Share of HBCD-containing EPS/XPS material was <b>similar for all countries</b>, unless other information were given (e.g. Sweden, France, UK)</p>	Period	HBCD	HBCD-free	Period	HBCD	HBCD-free	1955-1979:	0%	100%	2002-2014:	95%	5%	1980-1985:	75%	25%	2015:	75%	25%	1986-1990:	85%	15%	2016:	50%	50%	1995-2001:	90%	10%	2017-2050:	0%	100%
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1955	5.082 t	1965	77 t																																																	
1956	6.352 t	1966	97 t																																																	
1957	7.940 t	1967	121 t																																																	
...	...	...	...																																																	
Period	HBCD	HBCD-free	Period	HBCD	HBCD-free																																															
1955-1979:	0%	100%	2002-2014:	95%	5%																																															
1980-1985:	75%	25%	2015:	75%	25%																																															
1986-1990:	85%	15%	2016:	50%	50%																																															
1995-2001:	90%	10%	2017-2050:	0%	100%																																															
Sources	<p>Historical consumption data (Giraf results, resp. internal data) and production data + market estimations (BASF); GDP &amp; construction activity (Eurostat), demand (PEMRG)</p>	<p>HBCD-containing EPS amounts (year 2002) (BASF)</p>																																																		

# Forecast model (4/7)

## Forecast model of HBCD-containing EPS/XPS construction waste (2/2)



Variables	Application split	Return Flow	Waste
Assumptions / Criteria	<p>Application split is depending on country specific region: e.g. EPS application split in Germany</p> <ul style="list-style-type: none"> <li>■ ETICS</li> <li>■ Flat Roofs</li> <li>■ Flooring</li> <li>■ Perimeter</li> <li>■ Others</li> </ul>	<p>Due to different average life cycles of single applications (like ETICS, flat roofs, etc.) the <b>return of EPS and XPS waste amount is adapted/shifted</b> accordingly (e.g. in average most of EPS flat roof insulation becomes waste in 35 years, contrary perimeter insulation in 80 years)</p> <p>The forecast model is calculated with the same return flow for all countries despite of different construction methods and different geographical regions (esp. regarding climate).</p>	<p>HBCD-containing and HBCD-free EPS and XPS waste amounts until 2050 result from:</p> <ul style="list-style-type: none"> <li>■ EPS and XPS consumption</li> <li>■ HBCD-shares in EPS/XPS materials</li> <li>■ application split of total EPS and XPS consumption</li> <li>■ return flow (in %) of consumed EPS and XPS material</li> </ul>
Sources	<p>WDVS report Germany, BASF market study, interviews with demolition companies, associations e.g. IVH and ZDVH and other country-specific market experts</p>	<p>Fraunhofer-Institut, Rückbau, Recycling und Verwertung von WDVS, 2014, Strec EPS/XPS Recycling Baubereich, 2016; Interviews with national (EPS) associations, demolition companies and craftsmen etc.</p>	<p>Total EPS/XPS waste → internal studies e.g. EUMEPS, etc; total EPS/XPS HBCD-containing waste → e.g. Fraunhofer-Institut, UBA, etc.</p>



# Forecast model (5/7) – Explanation of life span assumptions

## Assumptions for Return flow for EPS (Assumption for XPS: Average useful life of EPS +5 years)

Application	Total Average Useful Life in years	Installation Waste	Return Flow EPS										Deprived Volumes <sup>1)</sup>	Total
			1-10 years	11-20 y	21-30 y	31-40 y	41-50 y	51-60 y	61-70 y	71-80 y	81-90 y	91-100 y		
ETICS	65	3%	1%	2%	3%	5%	7%	9%	14%	12%	10%	9%	25%	100%
Roof	35	3%	3%	10%	15%	17%	7%	6%	5%	4%	3%	2%	25%	100%
Flooring	75	3%	1%	2%	3%	4%	5%	6%	10%	12%	15%	14%	25%	100%
Perimeter	80	3%	1%	2%	3%	4%	5%	6%	8%	12%	16%	15%	25%	100%
Others	75	3%	1%	2%	3%	4%	5%	6%	12%	13%	14%	12%	25%	100%

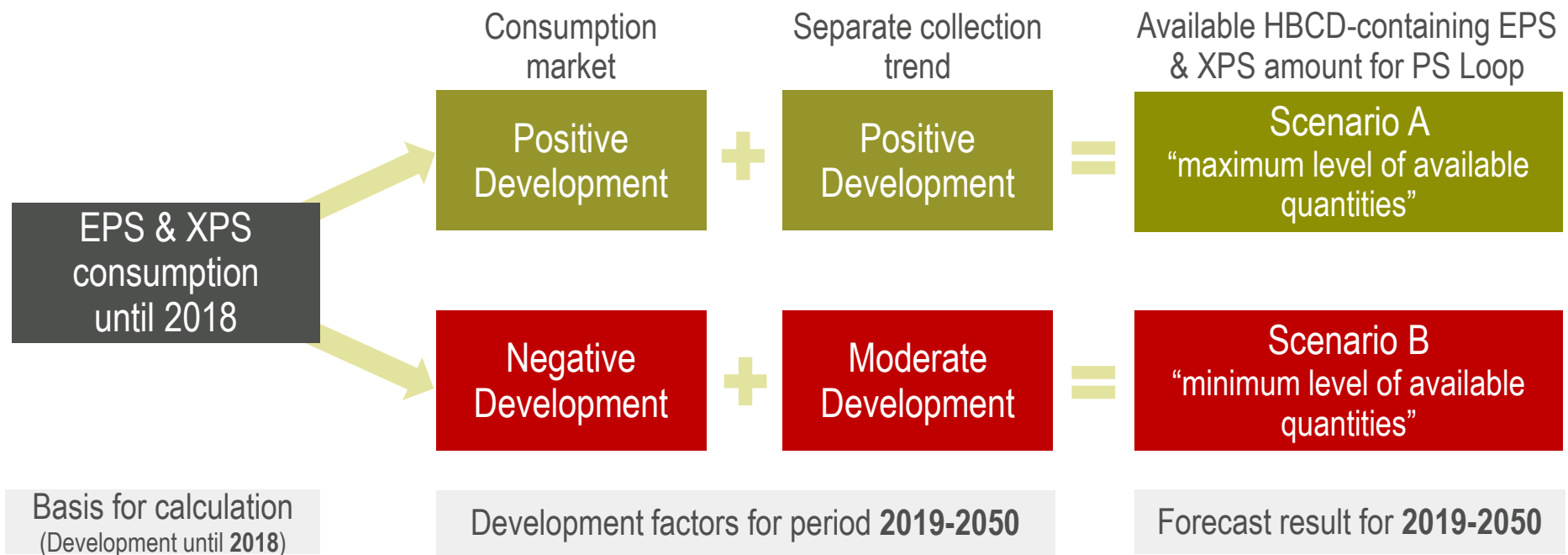
### Application Explanation of life span assumptions

ETICS	ETICS is mainly used for residential buildings because of advantages regarding energy savings. ETICS are very durable, this means that the average life span strongly correlates to the life span of the building. For commercial buildings, the life span tends to 40-50 years but for residual houses the life span shift to 70-80 years. In most cases ETICS is used for non insulated walls, the market share of ETICS usage on existing ETICS (“doubling”→ EPS layer already applied) is with about 5-10% on a lower level yet. In total 65 years average life-time is assumed, regarding usage of ETICS in commercial/residential buildings and doubling effect. [sources: UBA, Fraunhofer, iEMB, interviews with market experts]
Roof	EPS is the most used insulation material regarding insulation of flat roofs. This application also includes amounts of EPS material for pitched roof therefore the life span is slightly higher (~35 years) [source: interviews with market experts] Flat roofs are used in all types of buildings e.g. in single-family houses and apartments, but also in commercial and administrative buildings with a lower life span and higher renovation works. XPS is used for special types of flat roofs e.g. inverted roof.
Flooring	Usage of EPS insulation under the screed also for footstep sound insulation systems for flooring. XPS is used to insulate floors that are particularly heavily used, such as in warehouses, production halls and aircraft maintenance halls.
Perimeter	Only low usage of EPS for thermal insulation of building components and structures that come into contact with the ground. Especially below the base plate of a buildings XPS is used. EPS but also especially XPS is used for insulation on the outside of a basement wall. Therefore the high life span depends on the average life span of the building. Typically it appears in the mixed construction waste only in case of a structural restoration.
Others	Usage of EPS insulation for interior walls (also used as blow-in insulation). Life span comparable with other interior parts.

1) Deprived Volumes: EPS/XPS amount in buildings with a lifetime of more than 100 years, also amounts from construction parts that are not being demolished

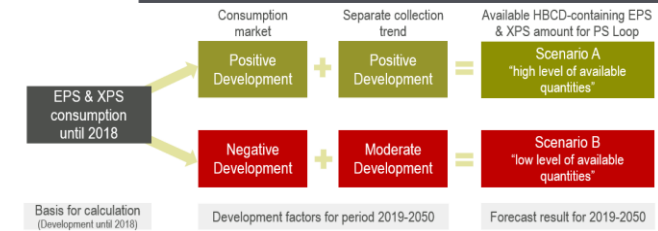
# Forecast model (6/7)

## Forecast model in scenario A and B (1/2)





# Forecast model (7/7)



## Forecast model in scenario A and B (2/2) – country-specific information see on p. 87-89

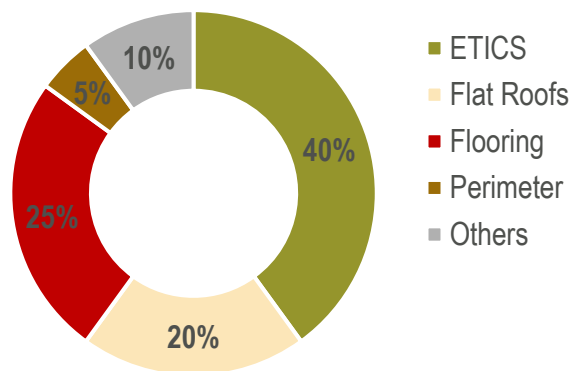
Variables	Scenario A "Growing construction sector with accelerated separate collection"	Scenario B "Decreasing construction sector with moderate separate collection"
<i>Basis:</i> <b>EPS &amp; XPS consumption</b> (until 2018)	Basis figures for calculation are the country-specific consumption data of total EPS/XPS for B&C (Sources: historical internal consumption data (same as giraf results data) & production data from BASF) Assumption: if no valid data were available, consumption figures were adapted by GDP, construction activity and/or demand	
<i>Development factor I:</i> <b>EPS/XPS consumption market</b> (2019-2050)	Assumed is a <b>positive trend</b> of EPS/XPS consumption <b>from 2019 to 2050</b> based on country-specific GDP, construction activity and/or demand averages (e.g. Germany: Annual increase of EPS consumption by 1.3%)	Assumed is a <b>negative trend</b> of EPS/XPS consumption <b>from 2019 to 2050</b> based on country-specific GDP, construction activity and/or demand averages (e.g. Germany: Annual decrease of EPS consumption by -1.3%)
<i>Development factor II:</i> <b>EPS/XPS waste separate collection</b> (2019-2050)	Assumed is a <b>positive development</b> of EPS/XPS separate waste collection based on country-specific separate collection in 2018 (derived from analysed waste streams). Because of increasing political actions a stronger growth can be expected.	Assumed is a <b>moderate development</b> of EPS/XPS separate waste collection based on country-specific separate collection in 2018 (derived from analysed waste streams). Today's situation for separate collection won't change significantly.
<i>Forecast result:</i> <b>Available HBCD-containing amount for PS Loop</b> (2019-2050)	The available HBCD-containing EPS & XPS quantities are in <b>scenario A</b> on a relative <b>high level</b> . Considering all waste streams in 2018, that collected HBCD-containing EPS/XPS waste separately (partially Commercial & Industrial waste stream, recycling center) the <b>available amount</b> /share was analysed. Assumed is a <b>positive increase by 5%</b> each 5 year (e.g. in Germany the separate collection share in 2018/2019 was 32% (basis); 2020-2024: 37%; 2025-2029: 42% etc.)	The available HBCD-containing EPS & XPS quantities are in <b>scenario B</b> on a relative <b>low level</b> . The available amount/share of HBCD-containing EPS/XPS waste in 2018 was analysed like in scenario A. Assumed is a <b>moderate increase by 1%</b> each 5 year (e.g. in Germany the separate collection share in 2018/2019 was 32% (basis); 2020-2024: 33%; 2025-2029: 34% etc.)



# Europe – EPS

## Assumptions for Forecast model of HBCD-containing EPS construction waste 2018 until 2050

EPS Split in Application (%)



### Annotations

- EPS insulation material has been **used since 1955** in Europe.
- The usage of **HBCD** in EPS insulation materials **started in 1980**.
- According to legal restrictions **HBCD hasn't been used since October 2015**.
- EPS is mainly used for **ETICS (40%)**, **flooring (25%)** and **roof insulation (20%)**.
- Due to **different average life cycles** of single applications (see table) the return of the EPS waste amount is adapted/shifted accordingly (e.g. in average most of EPS roof insulation becomes waste in 35 years, contrary perimeter insulation in 80 years)

Application	Total Average Useful Life in years	Installation Waste	Return Flow EPS										Deprived Volumes <sup>1)</sup>	Total
			1-10 years	11-20 y	21-30 y	31-40 y	41-50 y	51-60 y	61-70 y	71-80 y	81-90 y	91-100 y		
ETICS	65	3%	1%	2%	3%	5%	7%	9%	14%	12%	10%	9%	25%	100%
Flat Roofs	35	3%	3%	10%	15%	17%	7%	6%	5%	4%	3%	2%	25%	100%
Flooring	75	3%	1%	2%	3%	4%	5%	6%	10%	12%	15%	14%	25%	100%
Perimeter	80	3%	1%	2%	3%	4%	5%	6%	8%	12%	16%	15%	25%	100%
Others	75	3%	1%	2%	3%	4%	5%	6%	12%	13%	14%	12%	25%	100%

Sources: Fraunhofer-Institut "Rückbau, Recycling und Verwertung von WDVS", Strec EPS/XPS Recycling; Interviews with demolition associations, roofing associations, craftsmen etc.

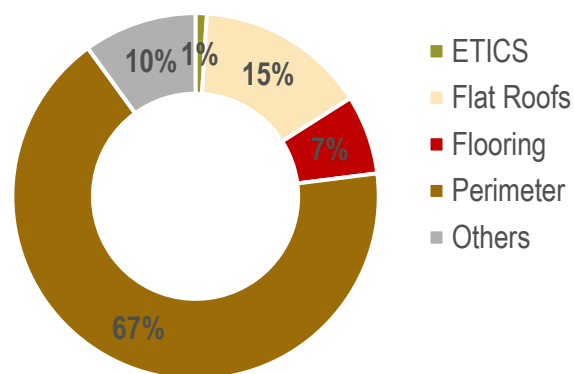
1) Deprived Volumes: EPS/XPS amount in buildings with a lifetime of more than 100 years, also amounts from construction parts that are not being demolished



# Europe – XPS

## Assumptions for Forecast model of HBCD-containing XPS construction waste 2018 until 2050 in t

XPS Split in Application (%)



### Annotations

- XPS insulation material has been **used since 1965** in Europe.
- The usage of **HBCD** in XPS insulation materials **started in 1980**.
- According to legal restrictions **HBCD hasn't been used since October 2015**.
- XPS is mainly used for **perimeter insulation (67%)**.
- Due to different average life cycles of single applications (see table) the return of the XPS waste amount is adapted/shifted accordingly. In general **XPS is more durable than EPS**.

Application	Total Average Useful Life in years	Installation Waste	Return Flow XPS										Deprived Volumes <sup>1)</sup>	Total
			1-10 years	11-20 y	21-30 y	31-40 y	41-50 y	51-60 y	61-70 y	71-80 y	81-90 y	91-100 y		
ETICS	70	3%	1%	2%	3%	4%	5%	6%	14%	13%	12%	12%	25%	100%
Flat Roofs	40	3%	3%	8%	11%	15%	10%	7%	6%	5%	4%	3%	25%	100%
Flooring	80	3%	1%	2%	3%	3%	4%	5%	8%	11%	18%	17%	25%	100%
Perimeter	85	3%	1%	2%	3%	4%	5%	5%	6%	8%	13%	25%	25%	100%
Others	80	3%	1%	2%	3%	3%	4%	5%	8%	11%	18%	17%	25%	100%

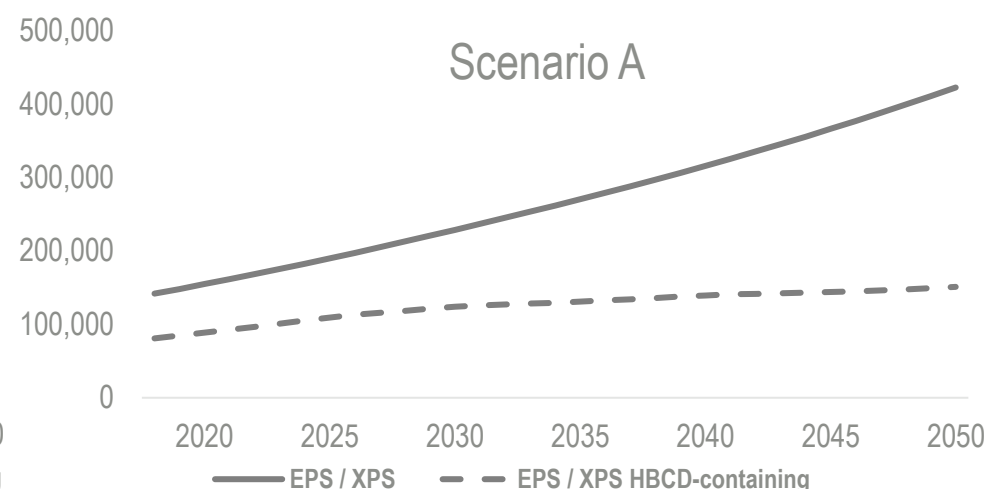
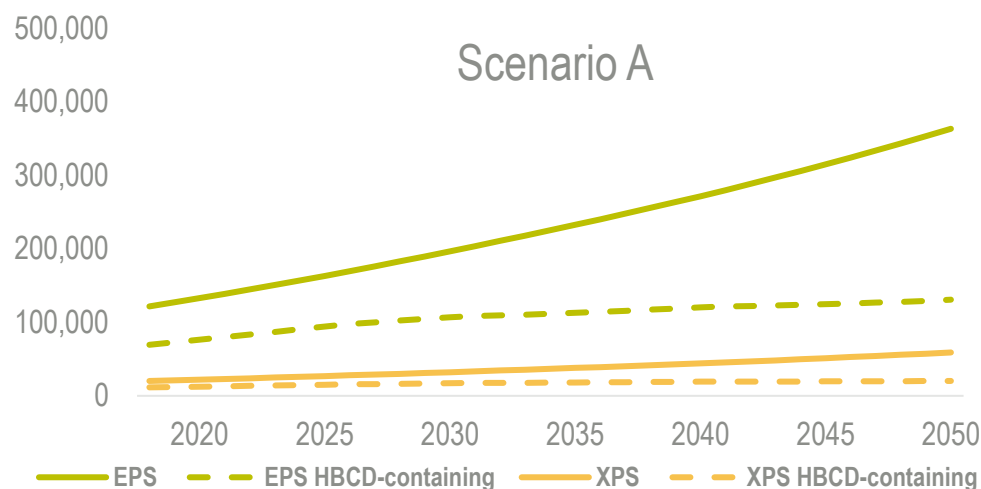
Sources: Fraunhofer-Institut "Rückbau, Recycling und Verwertung von WDVS", Strec EPS/XPS Recycling; Interviews with demolition associations, roofing associations, craftsmen etc.

1) Deprived Volumes: EPS/XPS amount in buildings with a lifetime of more than 100 years, also amounts from construction parts that are not being demolished



# Europe

Forecast of HBCD-containing EPS/XPS construction waste 2018 until 2050 in t

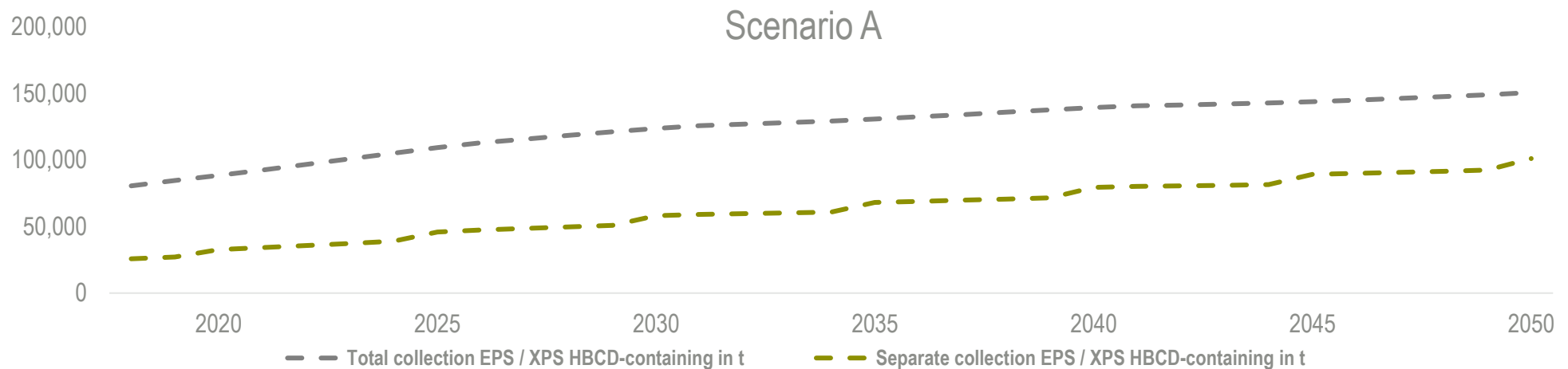


Scenario A	EPS in t	XPS in t	EPS / XPS in t	EPS HBCD-containing in t	XPS HBCD-containing in t	EPS / XPS HBCD-containing in t
2018	121,603	20,141	141,744	69,522	11,218	80,740
2020	132,874	21,916	154,790	76,287	12,262	88,549
2025	163,181	26,716	189,897	94,325	15,067	109,392
2030	196,709	32,032	228,741	106,767	17,039	123,806
2035	232,693	37,808	270,501	112,831	18,102	130,933
2040	271,701	44,078	315,779	120,256	19,185	139,441
2045	315,042	51,086	366,128	124,483	19,516	143,999
2050	363,513	58,902	422,415	130,814	20,031	150,845



# Europe

Forecast of available HBCD-containing EPS/XPS construction waste quantities 2018 until 2050 in t



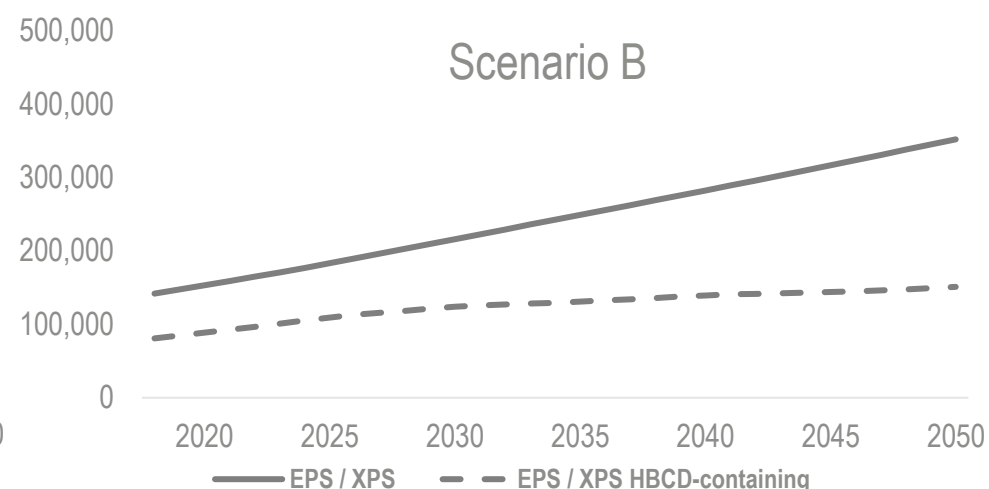
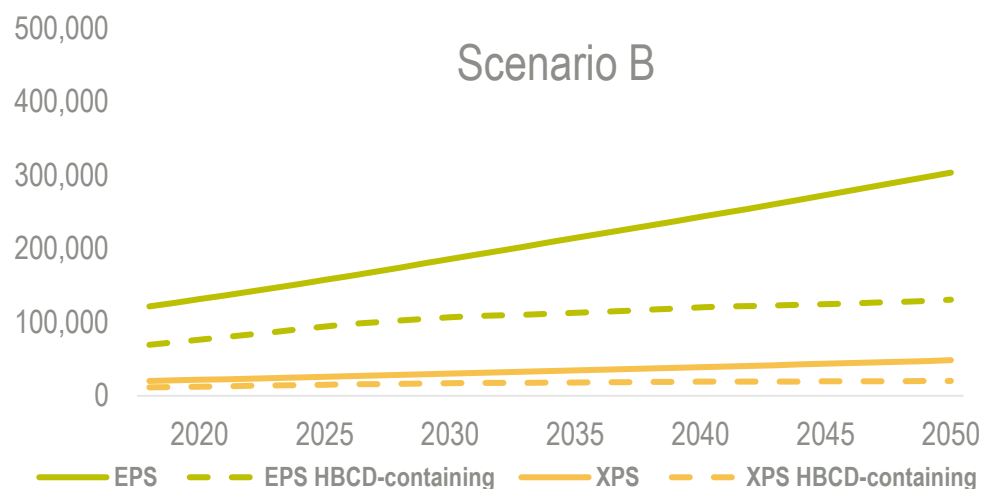
Scenario A	Total collection EPS / XPS HBCD-containing in t	Separate collection EPS / XPS HBCD-containing in t
2018	80,740	25,862
2020	88,549	32,790
2025	109,392	45,978
2030	123,806	58,227
2035	130,933	68,126
2040	139,441	79,524
2045	143,999	89,324
2050	150,845	101,113

 available for PSLoop



# Europe

Forecast of HBCD-containing EPS/XPS construction waste 2018 until 2050 in t

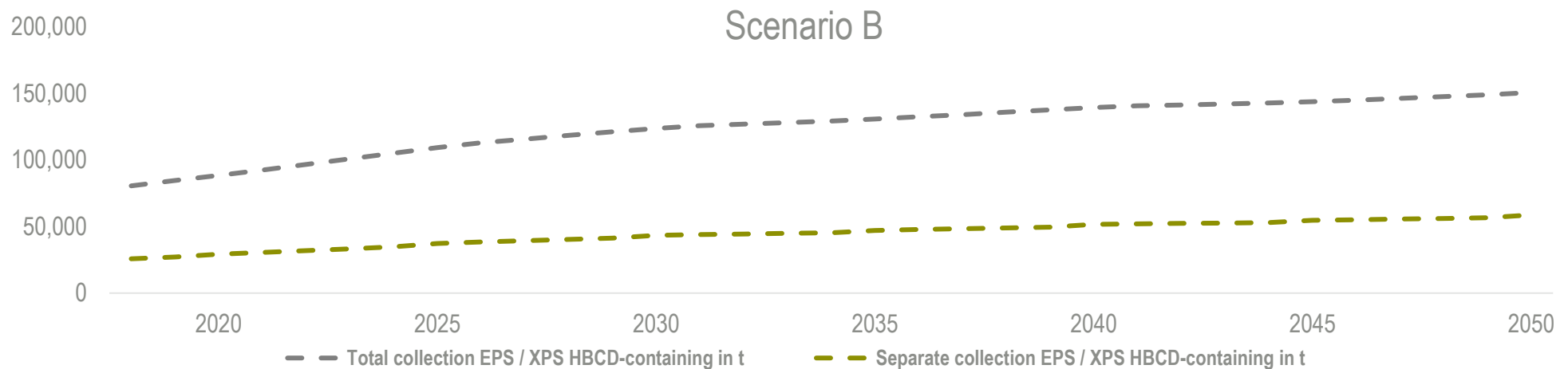


Scenario B	EPS in t	XPS in t	EPS / XPS in t	EPS HBCD-containing in t	XPS HBCD-containing in t	EPS / XPS HBCD-containing in t
2018	121,603	20,141	141,744	69,522	11,218	80,740
2020	131,447	21,632	153,079	76,287	12,262	88,549
2025	157,615	25,612	183,227	94,325	15,067	109,392
2030	186,017	29,933	215,950	106,767	17,039	123,806
2035	214,772	34,372	249,144	112,831	18,102	130,933
2040	243,469	38,823	282,292	120,256	19,185	139,441
2045	273,142	43,485	316,627	124,483	19,516	143,999
2050	303,825	48,305	352,130	130,814	20,031	150,845



# Europe

Forecast of available HBCD-containing EPS/XPS construction waste quantities 2018 until 2050 in t



Scenario B	Total collection EPS / XPS HBCD-containing in t	Separate collection EPS / XPS HBCD-containing in t
2018	80,740	25,862
2020	88,549	29,248
2025	109,392	37,227
2030	123,806	43,370
2035	130,933	47,176
2040	139,441	51,636
2045	143,999	54,764
2050	150,845	58,876

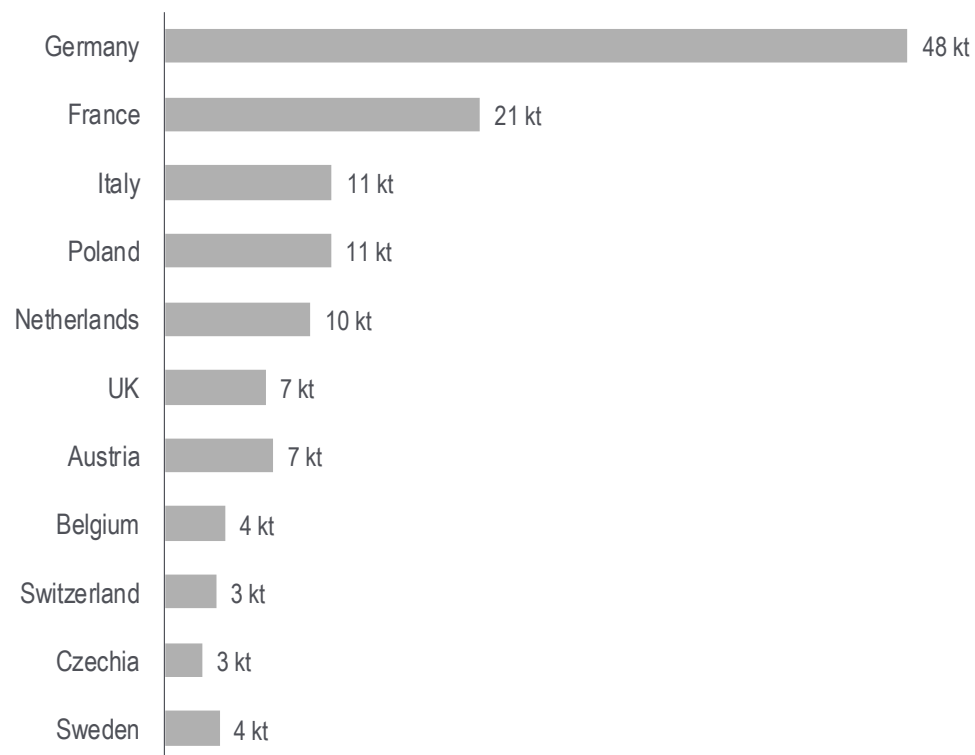
 available for PSLoop



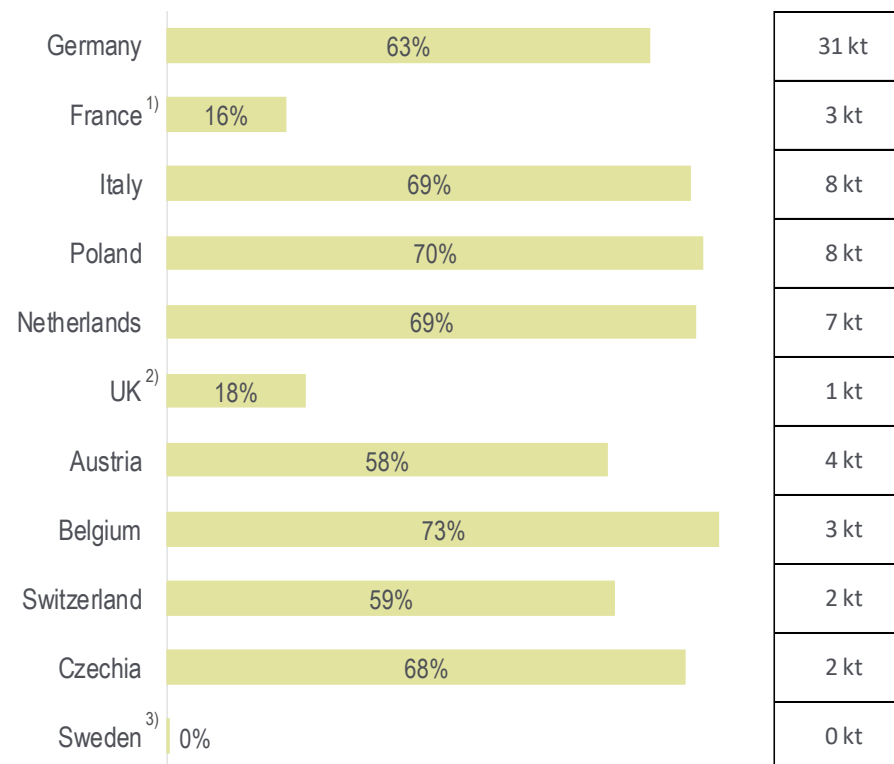
# European summary

## EPS/XPS HBCD-containing construction waste by countries in 2018

Total EPS/XPS construction waste in 2018



EPS/XPS HBCD-containing construction waste in 2018



<sup>1)</sup> Until 2010 almost no HBCD was used in EPS/XPS insulation material    <sup>3)</sup> In Scandinavia HBCD was not really used in EPS insulation materials – only 1% from 1980 until 2005.

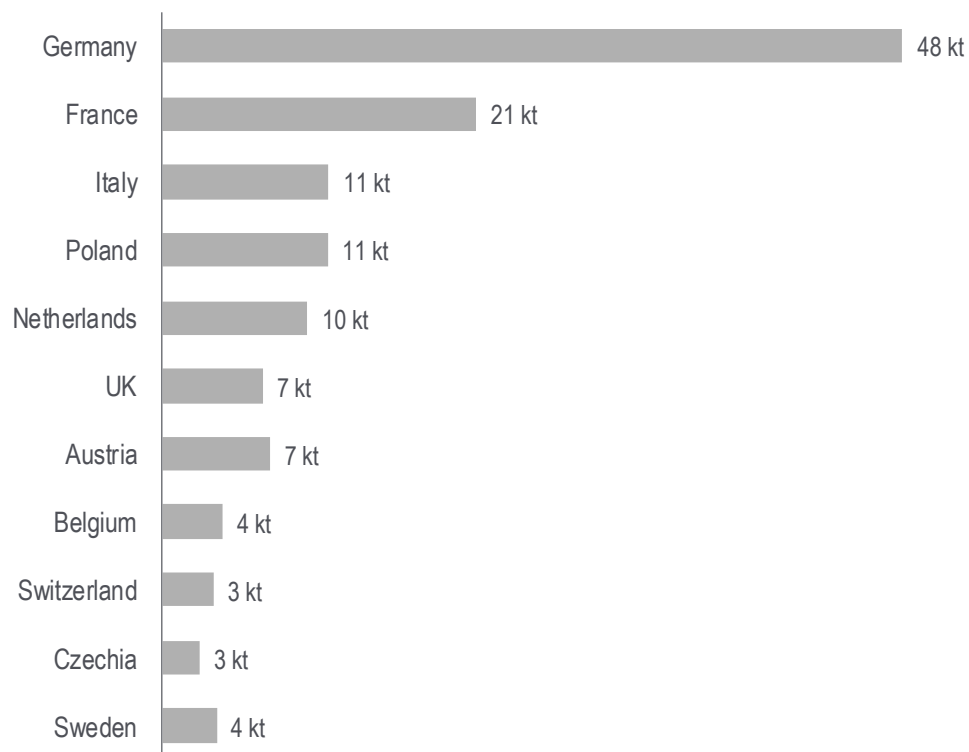




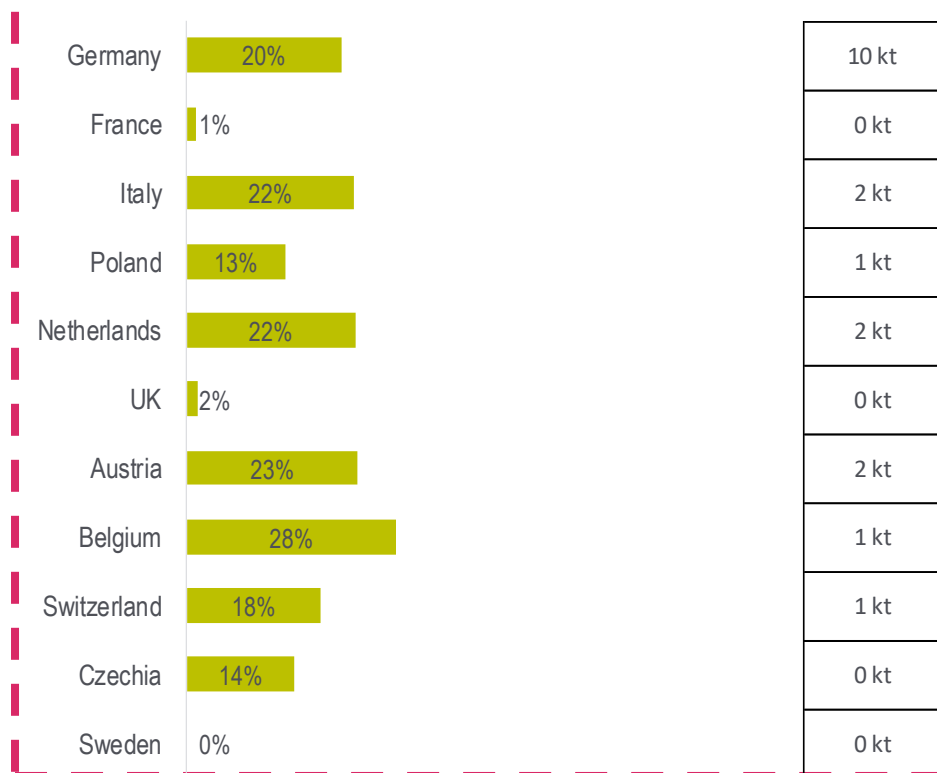
# European summary

## Available EPS/XPS HBCD-containing construction waste by countries in 2018

Total EPS/XPS construction waste in 2018



Available EPS/XPS HBCD-containing construction waste in 2018





# European overview 2030

## Forecast of HBCD-containing EPS/XPS construction waste quantities by countries in 2030

Scenario A	Total collection EPS / XPS waste in t	EPS / XPS HBCD-containing in t	Available EPS / XPS HBCD-containing in t	Scenario B	Total collection EPS / XPS waste in t	EPS / XPS HBCD-containing in t	Available EPS / XPS HBCD-containing in t
	70,441	41,493	<b>19,525</b>		67,443	41,493	<b>14,546</b>
	30,053	4,948	1,138		29,311	4,948	545
	27,366	14,574	<b>4,880</b>		22,545	14,574	<b>3,131</b>
	16,294	10,888	<b>5,161</b>		16,100	10,888	<b>3,855</b>
	15,478	9,448	<b>4,470</b>		14,898	9,448	<b>3,336</b>
	10,967	5,962	3,164		10,508	5,962	2,448
	10,046	1,861	358		9,472	1,861	135
	6,443	3,912	2,001		6,197	3,912	1,531
	5,887	26	0		5,503	26	0
	5,518	2,972	1,375		5,111	2,972	1,019
	5,389	2,945	1,068		4,893	2,945	715



# European overview 2050

## Forecast of HBCD-containing EPS/XPS construction waste quantities by countries in 2050

Scenario A	Total collection EPS / XPS waste in t	EPS / XPS HBCD-containing in t	Available EPS / XPS HBCD-containing in t	Scenario B	Total collection EPS / XPS waste in t	EPS / XPS HBCD-containing in t	Available EPS / XPS HBCD-containing in t
	116,186	41,211	<b>27,635</b>		97,675	41,211	<b>16,096</b>
	50,041	7,170	3,083		46,316	7,170	1,076
	66,272	22,615	<b>12,094</b>		40,207	22,615	<b>5,762</b>
	26,280	13,525	<b>9,116</b>		25,223	13,525	<b>5,329</b>
	26,273	9,565	<b>6,438</b>		22,779	9,565	<b>3,760</b>
	18,954	6,399	4,675		16,264	6,399	2,883
	19,056	2,424	951		16,031	2,424	273
	10,821	4,547	3,235		9,420	4,547	1,962
	10,417	29	0		7,180	29	0
	10,447	3,409	2,259		8,076	3,409	1,305
	11,664	4,697	2,651		9,214	4,697	1,336

# Agenda

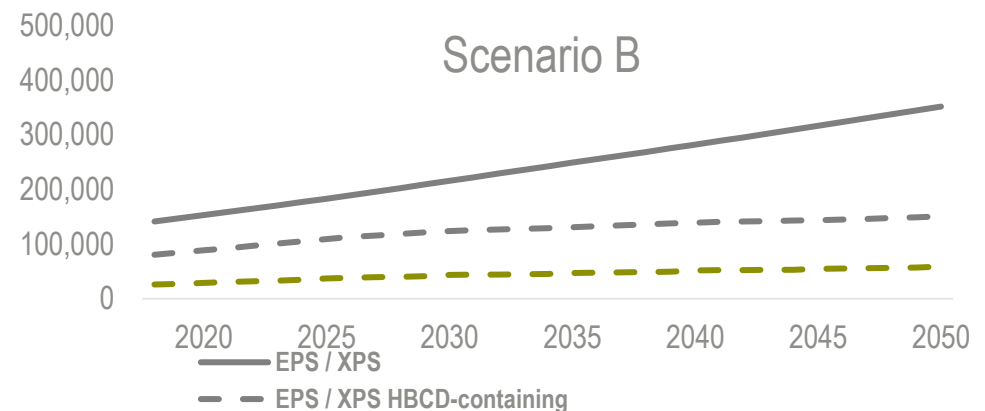
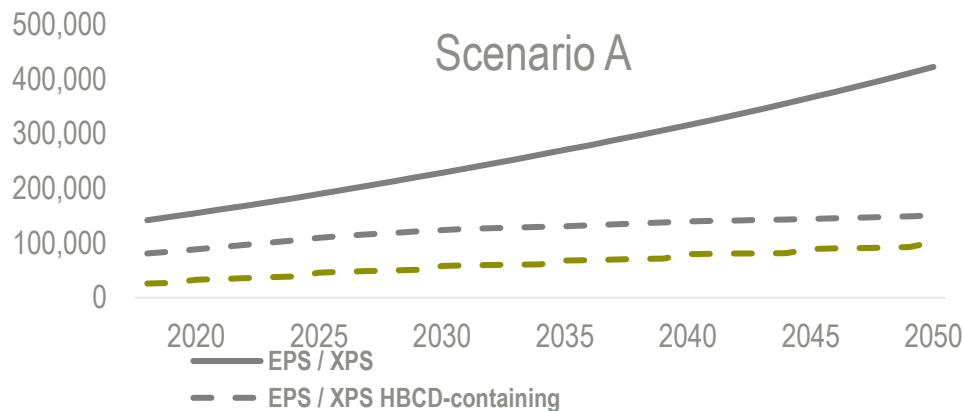
<b>Initial situation</b>	<b>3</b>
<b>Introduction &amp; Methodology</b>	<b>6</b>
<b>European Summary</b>	<b>14</b>
<b>HBCD-containing EPS/XPS post-consumer waste quantities – example Germany</b>	<b>20</b>
<b>Forecast model about EPS/XPS construction waste containing HBCD by 2050</b>	<b>25</b>
<b>Management Summary</b>	<b>44</b>

# Management Summary

## Status quo

In general a **positive trend** of European EPS construction waste collection and recycling activities is feasible. Around 142kt EPS/XPS was collected in 28+2 European countries 2018. Compared to 2017 the **total quantity increased** by 2.2%. In 2018 about 14kt (~10%) was recycled, ca. 95kt (~67%) energy recovered and 33kt (~23%) landfilled.

## Forecast



In 2018 some HBCD-containing EPS/XPS amounts were already collected separately at recycling centres or the construction sites. Because of increasing legal restrictions and environmental awareness these **separate collected HBCD-containing EPS/XPS amounts of ~26kt** in 2018 are assumed to grow in future. For feeding the PSLoop plant separate collected quantities of ~101kt in 2050 **will be available** for scenario A (scenario B about 59kt in 2050).

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## Publications:

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Giraf results, HBCDD concentrations in EPS/XPS products and waste streams, 2018

ICL-IP Europe BV, TEMPLATE for third party submission of information on alternatives for Applications for Authorisation HBCD use in EPS for Building Applications, 2014

PlasticsEurope, End-of-life treatment of HBCD-containing polystyrene insulation foams, 2014

PolyStyreneLoop, Guideline on the Collection and Pre-treatment of polysterene foams for PolyStyreneLoop, 2019

STREC, EPS/XPS Recycling Baubereich, 2016

UBA, Identification of potentially POP-containing Wastes and Recyclates – Derivation of Limit Values, 2015

UBA, HBCD – Antworten auf häufig gestellte Fragen, 2017