Report summary construction products

Contents

1. Uses / Applications

The uses, sub-uses and functions of PFAS identified by Glüge et al. (2020)[1] act as a starting point for categorisation of PFAS uses in construction products. These uses have therefore been grouped into three tiers of hierarchy:

- Parent level
- Sub-level
- Application specific level.

At parent level, two categories are defined:

- Coatings: This covers PFAS containing mixtures applied to a pre-existing article.
- Products: This covers the use of PFAS or PFAS containing mixtures used within a complete product (article).

In Table 1 the identified uses are given.

Table 1. Identified uses of PFAS in construction products.

Parent level	Sub-level	Application specific level
Construction Products (products) Definition: This category covers products that already contain PFAS to provide a specific function. Examples may include PTFE, PVC, other plastics, and cabling. The distinction is that the article comes as a complete item that already contains PFAS.	• Building and construction	• Architectural membranes e.g. in roofs, greenhouses, flexible solar panels • Windows and window frames (containing e.g. ETFE & PTFE) (e.g. greenhouses) • Cement additives[2] • Cable and wire insulation, gasket hoses • Skidways for constructions (e.g. PTFE) • Bridge bearings (e.g. PTFE) • Sealants and adhesives
	• Pipes, pumps, fittings, and liners	• Pipe linings • Working fluid/vacuum pump oils
	• Household application	• PTFE tape (also PTFE tape for professional applications like for drinking water and compressed air systems) • DIY sealant and adhesive products
	• Processing aids	• Processing aid in the manufacture of construction products

[1] Glüge, Juliane & Scheringer, Martin & Cousins, Ian & DeWitt, Jamie & Goldenman, Gretta & Herzke, Dorte & Lohmann, Rainer & Ng, Carla & Trier, Xenia & Wang, Zhanyun. (2020). An overview of the uses of per- and polyfluoroalkyl substances (PFAS). 10.31224/osf.io/2eqac.

[2] This use was identified by Glüge et al. (2020) but note that the cement industry suggested during the consultation that they are not aware of intentional use of PFAS in their industry.

Construction Products (surface coatings) Definition: This category covers the use of coatings (including sprays, paints, mixtures and fully PFAS based thin film technologies) added to pre-existing articles at the time of use or at the end of production as a finishing process to give the component desired water, oil and dirt repellent properties. It also includes the addition of PFAS within other coating mixtures (such as paints) as a surfactant/wetting agent/levelling agent.	• Wood industry sector	• Coatings-paintings-varnishes - Wood substrate • Coatings-paintings-varnishes - Resin for particleboard
	• Glass industry sector	• Surface treatment of glass
	• Metal industry sector	• Coatings-paint for metal protection
	• Construction sector plastics	• Professional coatings for finishing step of plastics used in construction
	• Outdoor electrical components	• Surface coatings for wind turbine blades • Surface coatings for solar panels
	• Stone, concrete, and tiles - Semi-professional aftercare	• Surface treatments • DIY durable water repellent (DWR) impregnation
	• Coatings, paints, and varnishes - Domestic / semi-professional aftercare	• Paints • Coatings (glass, ceramic, and metal) • Linoleum, laminated plastic floor[3] • Aftermarket floor protection

2. Main PFAS

Construction products (articles)

32 different PFAS species, both polymeric and non-polymeric were identified as being used within construction product applications in articles, according to stakeholder input during the Call for Evidence (CfE) and the targeted stakeholder consultation, as well as literature review. For the majority of cases, the CfE has yielded sufficient data to identify the substances used at the application-specific level (not shown to protect confidentiality) with a few exceptions. At the parent level (articles), Glüge et al. (2020) estimated by volume approximately an even split between polymeric and non-polymeric PFAS in use.

Construstion products (mixtures used as coatings)

57 different PFAS species were identified from the CfE and the targeted stakeholder consultation, as well as the literature review at the sub-level use category, as data on the more detailed application-specific level was less complete. For all uses except paints, only polymeric species were identified.

[3]This use was identified by Glüge et al. (2020), but note that the flooring industry suggested that the only significant uses of PFAS in their industry have been phased out since the early 2000s.

2.1 Tonnages bands

Based on SPIN Database (not specified per substance group)

Based on the SPIN (Substances in Preparations in Nordic Countries) database, Glüge et al. (2020) estimated that around 1,500 t of PFAS[4] were used in building and construction in Sweden, Finland, Norway, and Denmark between 2000 and 2017. Additionally, a further 3,500 t of PFAS were used in paints and coatings for the same countries and timeframe. Extrapolating the tonnages yields an estimate of around 1,600 t of PFAS used in building and construction and 3,700 t of PFAS used in paints and coatings in the EEA per year on average.

Information from various other sources

- It is noted that official statistics on production and trade (e.g., Eurostat Prodcom or Comext data) are not sufficiently detailed to identify PFAS-based construction products.
- As polymers are exempt from registration under REACH, and a lot of PFAS-based construction products are based on polymeric PFAS, tonnage bands from ECHA's database of registered substances are considered not useful.
- The CfE identifies approximately 20 non-polymeric PFAS substances in use, but with no tonnage data provided.

Based on stakeholder consultation

Table 2 shows an overview of the tonnages of PFAS manufactured or imported into the EEA, based on the CfE and targeted stakeholder consultation.

[4] Note that the definition of PFAS used in Glüge et al (2020) is largely consistent but not identical to the definition used for the present study. This may lead to differences in tonnages of PFAS identified in the uses in question. Glüge et al (2020) focuses on polymeric PFAS with the –CF2– moiety and non-polymeric PFAS with the–CF2–CF2–moiety. This does not include non-polymeric substances that only contain a –CF3 or –CF2–moiety, with the exception of perfluoroalkylethers and per- and polyfluoroalkylether-based substances. For these two PFAS groups, substances with a –CF2OCF2– or –CF2OCFHCF2– moiety are also included.

Table 2. Total tonnages of PFAS manufactured or imported into the EEA for use in the construction sector, based on the CfE and targeted stakeholder consultation.

PFAS	PFAS in construction products manufactured in the EEA (tonnes)			PFAS in construction products imported into the EEA (tonnes)			Suppliers reported to manufacture/import PFAS containing construction products or PFAS for use in construction products
	Mid-value of range	Range	Number of respondents providing data	Mid-value of range	Range	Number of respondents providing data	
PTFE	3,950	1,715 – 6,185	9	148	60 - 235	4	Chemours, 3M, Trelleborg, HaloPolymers, AGC
EFTE	2,040	1,950 – 2,135	4	444	398 – 490	4	3M, Membrana, Solvay
PVDF	Confidential	Confidential	2	Confidential [5]	Confidential	1	Chemours, 3M, Arkema, Solvay
PFA	75	65 – 85	3	Confidential	Confidential	1	3M, Solvay
FEP	Confidential	Confidential	2	-	-	-	Chemours, 3M
Acrylate based side chain fluoropolymer	26.6	13 – 40	4	-	-	-	Chemours, Daikin, Maflon, Wacker chemie AG
FKM / FFKM	8	1.2 – 15	5	-	-	-	DuPont, Fluorocarbon,
THV	Confidential	Confidential	1	-	-	-	3M
HFP	Confidential	Confidential	1	-	-	-	No data
other non-polymeric PFAS	6	1 - 12	12	1	-	-	Solvay (PFPE, and sulfonic acids), Chemours (sulfonic acids), Gore (sulfonic acids + additives), Delta-seal (unclear – potentially resins), 3M (<C6 chemistry), Moeller (unknown – stone protection product), Confidential stakeholder ("C6 fluorosurfactant")

[5] Note that for the emission scenarios a quantity for the imported amount of PVDF is calculated.

Based on time-series estimations

Table 3 shows the estimated uses of different PFAS-species between 1990-2050. Note that, although some data was available, various assumptions were made to develop the estimates. Below the table more information can be found on the assumptions for the past and future usages.

Table 3. Tonnages used in the EU for construction products.

Group	1990	2000	2010	2020 (baseline)	2030 (BAU)[1]	2040 (BAU)	2050 (BAU)
PTFE (Granular)	1,551	1,715	2,331	3,895	6,341	8,118	8,967
PTFE (Micropowder)	0.0	0.0	76	205	8	9	10
EFTE	819	1,002	1,227	2,480	4,658	5,963	6,587
PVDF	221	271	332	550	902	1,155	1,276
Other Fluoropolymers	192	213	235	260	333	426	471
Non-polymeric PFAS (all substances)	6,309	8,555	9,854	10,900	12,036	13,295	14,686

1: BAU Business as Asual

Backward-looking time series

- PTFE: growth 1990-2005 increases at 1% per annum. From 2005 – 2020, growth accelerates to 5% per annum, as the advent of PTFE micropowder accelerates potential use, particularly in mixtures.
- EFTE: growth 1990 – 2010 increases at 2% per annum as EFTE becomes a strong alternative to PTFE. 2010 – 2014 growth at 5% per annum. 2014 – 2020 growth at 8% per annum as indicated by the Statista (2020)[6] reference.
- PVDF: growth 1990 – 2010 increases at 2% per annum as PVDF becomes a strong alternative to PTFE. 2010 to 2020 growth at 5%. The EEA (2020) report suggests that PVDF is one of the most rapidly growing fluoropolymers due to its hard wearing anti-abrasion properties.
- Other fluoropolymers: growth 1990 – 2020. In lieu of data assume growth of 1% per annum.
- Non-polymeric PFAS substances (note that this covers a very wide range of substances): 1990 – 2002, assume growth of 3% broadly in line with inflation. Assume growth between 2002 and 2020 is 1% per annum as tighter regulation suppresses the market.

Forward-looking time series

- PTFE: asssumed continued growth at 5% per annum until 2030, after which growth slows to 2.5% between 2030 and 2040 and slows further to 1% per annum between 2040-2050.
- EFTE: assumed growth of 8% per annum until 2025, after which growth slows to 5% (in line with PTFE) until 2030. The growth pattern then mirrors PTFE as growth of 2.5% annually between 2030 and 2040 and 1% per annum thereafter between 2040-2050.
- PVDF: mirrors the growth pattern for PTFE (5% annually between 2020 and 2030, then 2.5% between 2030 and 2040, and 1% between 2040 and 2050).
- Other fluoropolymers: assumed growth of 2.5% per annum between 2020 and 2040, after which it falls in line with the other fluoropolymers as a rate of 1% per annum between 2040 and 2050.
- Non-polymeric PFAS: is assumed to have a flat increase of 1% per annum from 2020 to 2050, assuming the market continues to be suppressed by the existing restrictions on a number of PFAS species.

[6] https://www.statista.com/statistics/732029/ethylene-tetrafluoroethylene-market-volume-worldwide/

- Other contaminants: The production of PTFE using processing aids can contain PFOA as a trace contaminant (Wang et al, 2014[7]). Equally, the CfE highlighted the possible presence of PFHxA as a contaminant in EFTE.
    - PFOA emissions are calculated at 2% w.w based on the work by Wang et al (2014) from 1990 – 2015. The projections assume that after 2015, remaining sources of PFOA in PTFE fall to 1,000 ppb (which covers the restriction for PFOA and its related compounds).
    - PFHxA is currently subject to a REACH restriction process which commenced in late 2019. For the projections, it is assumed that the transitional period under the REACH restriction will have concluded by the 1 January 2026. After this date it is assumed any further emissions would be negligible and therefore are assumed to be close to zero
- Note that no considerations of changes in technology, abatement, or unpredicted events (such as Covid-19) are included within the estimates.

3. Manufacturing & Market price + market development

3.1 Market price

No information is given on market price.

3.2 Market development

PTFE micro-powders

The EU is currently in the process of implementing a restriction on the intentional use of microplastics with the combined opinion of the RAC and SEAC presented to the Commission in February 2021. Based on this some applications of PTFE micropowders, that are believed to exist in the 0.25 - 500µm (0.5mm) range, fall well within the scope of the microplastic restriction. [8] The implementation of the restriction for the intentional use of microplastics is conservately estimated to be 2026. ECHA indicate that a vote on the restriction will likely take place in 2022 (assuming that current timetable is upheld). The implementation of a restriction would also likely include a transition period of 3-5 years to allow industry to transition away from current uses.

PTFE can be used as a granular product, a micropowder and potentially a dispersion. A review of publicly available data on the internet (including SDS) suggests that PTFE micropowder is primarily used in mixtures for surface coatings and sealants. It is also possible to use PTFE micropowder as a raw material in 'melt processes' to produced moulded products. However, insufficient data has been identified to help provide market splits. It is assumed that PFTE micropowder could be subsituted by PTFE as a granular prodct if they were not already using it in this form. The impacts of the restriction on construction articles is therefore unclear.

EFTE-powders

Review of company websites and SDS have also identified limited data that suggests EFTE could also be used as a fine powder within construction mixtures. The prevalence of fine powder EFTE use within the market has been challenging to estimate.

[7] Wang et al, 2014, 'global emission inventories for C4-C14 perfluoroalkyl carboxylic acid (PFCA) homologues from 1951 to 2030 part I: production and emissions from quantifiable sources', Environmental international vol 60 pp242-248

[8] RAC and SEAC, 2020, 'Opinion on the Annex XV dossier proposing restrictions on intentionally added microplastics', Revision 5 – 10 December 2020.

3.3 Production sites

No exact information is given on the number of production sites. However, little information is given on the production of PTFE:

- Based on the production and use of PTFE, associated PFOA emissions are calculated at 2% w.w based on the work by Wang et al (2014) from 1990 – 2015, at which time the PFOA stewardship program phased-out the use of PFOA amongst the largest eight global producers. As the PFOA stewardship program did not cover all PTFE production globally, and Wang et al (2014) highlight new producers after 2015, it is assumed that PFOA may still be released from imported PTFE. Historically PFOA has been used as a processing aid in the manufacture of some types of PTFE, with much of the PTFE production taking place outside of the EU (Wang et al, 2014).

4. Emissions product manufacturing and product use

4.1 General

Within this section and the coming sections (emissions product manufacturing and emissions product use) the PFAS species are divided into two majour groupings:

- Polymeric fluorochemical substances
- Non-polymeric fluorochemical substances

Polymeric fluorochemical substances

The polymeric fluorochemical substances are further categorized in four major groupings:

- PTFE (polytetrafluoroethylene)
- EFTE (ethylene tetrafluoroethylene)
- PVDF (polyvinylidene fluoride)
- Other fluorpolymer substances

This categorisation has been used as the first three substances make-up 97% of the reported total usage of fluoropolymers in the construction sector while the latter covers 3% of the usage.

Non-polymeric fluorochemical substances

For the non-polymeric substances, the picture is more complex with a wide range of substances identified as potentially being in use covering fluorotelomer alcohols, acrylates, methacrylates, alkanes, amines, and silanes. The dominant species (based on frequency of respondents reporting its use) was perfluoro-1-butanesulfonyl fluoride (PBSF) and PBSF-related substances, which has applications, primarily as a surfactant and levelling agent for paints, but has also been identified as used in adhesives and sealants (tapes).The lack of granularity for market data on specific named non-polymeric fluorochemical substances, means that in this section and coming section they are grouped together and simply referred to as non-polymeric PFAS.

4.2 Emissions baseline year

The estimated emissions to air, water and land of different PFAS-species are given for articles, processing aids and commercial construction mixtures in Table 4, Table 5 and Table 6, respectively.

Note that emissions to the environmental compartments splitted by product manufacturing and product use are not given in the report and are therefore shown combined. Information on the assumptions made and corresponding justifications for these are given further on in this document (Table 8 and Table 10).

Table 4. Overview of estimated yearly EEA emissions for 2020 (baseline) by receiving environment for articles. This table includes product manufacturing and use.

Group	Quantity in use in EU (tonnes)	Emissions to air (tonnes)	Emissions to water (tonnes)	Emissions to land (tonnes)	Total Emissions
PTFE (granular)	3,895	96	58	152	306
EFTE	2,360	50	35	84	169
PVDF	525	12	8	20	40
All other fluoropolymer substances	250	6	4	10	20
All non-polymeric PFAS substances	3,700	94	55	147	296

Table 5. Overview of estimated yearly EEA emissions for 2020 (baseline) by receiving environment for processing aids. This table includes product manufacturing and use.

Group	Quantity in use in EU (tonnes)	Emissions to air (tonnes)	Emissions to water (tonnes)	Emissions to land (tonnes)	Total Emissions
All non-polymeric PFAS substances	3,700	4.0	0.0	1.0	5.0

Table 6. Overview of estimated yearly EEA emissions for 2020 (baseline) by receiving environment for commercial construction mixtures. This table includes product manufacturing and use.

Group	Quantity in use in EU (tonnes)	Emissions to air (tonnes)	Emissions to water (tonnes)	Emissions to land (tonnes)	Total Emissions
PTFE (granular)	205	15	7.5	7.5	30
EFTE	120	9	4.5	4.5	18
PVDF	25	2	1	1	4
All other fluoropolymer substances	10	1.0	0.5	0.5	2.0
All non-polymeric PFAS substances	3,500	256	129	129	514

4.3 Emission estimates time-series

In Table 7 the estimated emission of each PFAS-group for the period 1990-2050 is given per receiving environmental compartment. No information was available to allocate the releases to the different life stages of the construction products.

Table 7. Yearly emissions in the EU by vector (tonnes) including projections for BAU (Business as Usual).

Group	Vector	1990	2000	2010	2020 (baseline)	2030	Group	Vector
PTFE (Granular)	Air	38	42	57	96	156	199	220
	Land	60	67	91	152	247	316	349
	Water	23	26	35	58	94	121	133
PTFE (Micropowder)	Air	0	0	5.5	15	0.6	0.7	0.7
	Land	0	0	2.8	7.5	0.3	0.3	0.4
	Water	0	0	2.8	7.5	0.3	0.3	0.4
EFTE	Air	19	24	29	59	109	140	154
	Land	29	36	44	89	166	213	235
	Water	13	16	20	40	75	96	106
PVDF	Air	6	7	8	14	23	29	32
	Land	8	10	12	21	34	43	48
	Water	4	4	5	9	15	19	20
Other fluoro-polymers	Air	5	6	7	7	9	12	13
	Land	8	8	9	11	13	17	19
	Water	3	3	4	5	5	7	7
PFOA (as by-product of PTFE (all types) (in kg)	Air	760	830	1,260	0.1	0.1	0.2	0.2
	Land	1,200	1,320	1,870	0.2	0.3	0.3	0.3
	Water	460	500	750	0.07	0.09	0.1	0.1
PFHxA (as by-product of EFTE) (in kg)	Air	7.2	9	11	22	0	0	0
	Land	11	13	17	32	0	0	0
	Water	4	5	7	13	0	0	0
Non-polymeric PFAS	Air	203	275	317	350	387	427	472
	Land	160	211	250	277	305	337	373
	Water	106	140	166	184	203	224	248

4.4 Overview of the emissions

In Figure 1 and Figure 2 an overview can be found of the yearly material flows for polymeric PFAS and non-polymeric PFAS, respectively. The emissions are given for the different stages in the life cycle of construction products.

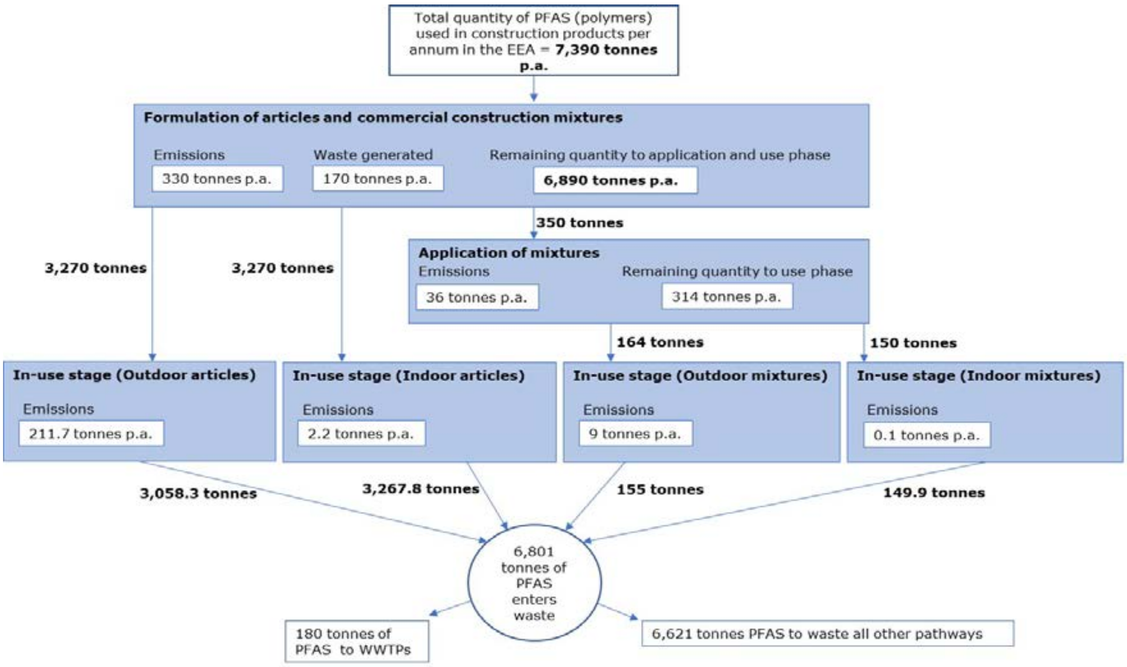

Figure 1. Overview of yearly EEA material flow for all polymeric PFAS used in construction products.

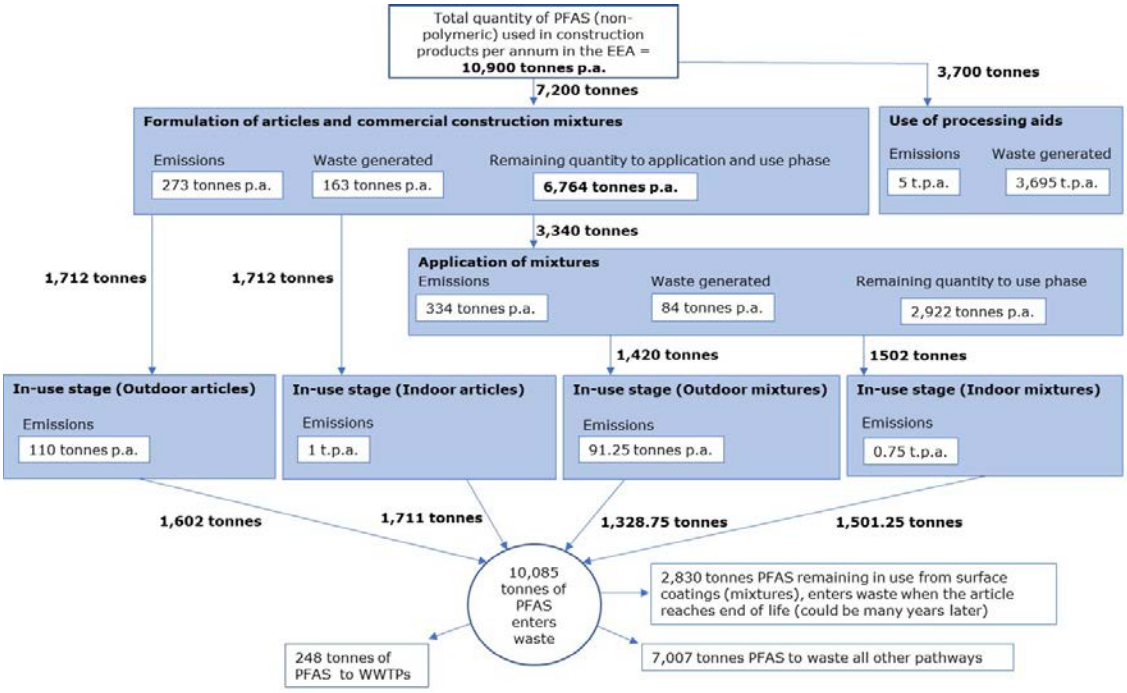

Figure 2. Overview of yearly EEA material flow for all non-polymeric PFAS used in construction products.

4.5 Emissions product manufacturing

For construction products three major categories were identified to subdivide the emissions of different PFAS-species. These will be used to categorize the emissions during product manufacturing and product use. The categories are as follows:

- Articles
- Processing aids
- Commercial construction mixtures

In Table 8 the assumptions used to calcalute the emissions during product manufacturing are given. Aditionally, the justifications for these assumptions are given. In Table 9 the emissions are presented.

Table 8. Key assumptions and justifications for calculation of emissions during product manufacturing.

Component	Value	Assumption and Justification
Formulation (Type 1) covering the production of articles containing or made from fluoropolymer and non-polymeric PFAS	Quantities of PFAS (by group) used. PTFE (granular) = 3,750 tpa EFTEs = 1,940 tpa PVDF = 475 tpa Other fluoropolymer substances = 250 tpa Non-polymeric PFAS = 3,700 tpa	Assumption: The market data pro-vides usage rates for different PFAS groupings as a range. In each case the upper limit of the range has been used. Justification: Assumes a worst case scenario and utilises the maximum amount of PFAS for each grouping.
Formulation (Type 1) covering the production of articles containing or made from fluoropolymer and non-polymeric PFAS	For fluoropolymer and non-polymeric PFAS emission factors based on Environmental Release Category (ERC) no.12A: Air = 2.5% Wastewater= 2.5% Soil = 2.5%	Assumption: Data on emissions dur-ing formulation of articles is very scarce. Feedback from stakeholder under the CfE commented that dust minimisation and capture is used as a standard practice to control emis-sions and prevent worker exposure. In lieu of better data ERC no.12A has been used covering: 'Processing of articles at industrial with low release'. Justification: Estimates for releases is very limited, feedback from industry asserts that emissions are very low and efforts are made to capture and control any dust or vapours generat-ed. The selected ERC default emis-sion factor best represents this set of activities.
Formulation (Type 2) covering the production of commercial construction mixtures containing or made from fluoropolymer and non-polymeric PFAS	Based on total use – PTFE (micropowder) = 200 tpa EFTE = 100 tpa PVDF = 25 tpa Other fluoropolymer substances = 10 tpa Non-polymeric PFAS = 3500 tpa	Assumption: Glüge et al (2020) com-ments that 95% of paints and surface coatings are non-polymeric, assum-ing the remaining 5% are fluoropoly-mers. The extrapolated values from Glüge et al (2020) (3,700 tonnes per annum) have been used to apportion between polymeric and non-polymeric. The polymeric substances have then been further disaggregated based on the ratios between PTFE and the other major fluoropolymers. Justification: Extrapolation of key references and data provided through the CfE has been used to estimate quantities in use, due to a lack of good quality market data.

Component	Value	Assumption and Justification
Formulation (Type 2) covering the production of commercial construction mixtures containing or made from fluoropolymer and non-polymeric PFAS	Use ERC emission scenario no.2 for 'formulation into a mixture' 2.5% w.w to air 2% w.w to wastewater and 0.01% w.w to soil.	Assumption: Data on emissions dur-ing formulation of mixtures (including blending and elevated temperatures) is very limited. In lieu of presentative data ERC emission factors have been used as standard defaults to help guide the estimates. Justification: Formulation of mixtures spans a wider set of applications from paints, adhesives sealants and com-mercial mixtures used to treat articles. It is likely that emissions will vary on a process by process basis, but as a high level approach, the use of ERC default emission factors is justified.
Processing aids (Formulation Type 3)	Assume use quantity: 3,700 tonnes of non-polymeric PFAS.	Assumptions: Very little available data to guide on the use of non-polymeric PFAS in production of articles (Gluge et al (2020) identifies a broadly even split between polymer and non-polymer). In lieu of better data assume that half of all non-polymeric PFAS is used as processing aids in the pro-duction of articles. Justification: There is limited detail on this topic, however, the high majority of feedback for the use of non-polymeric PFAS in the CfE relates to the use as processing aids in the production of other articles. In some cases, these substances are used with fluoropolymers such as PTFE and in other cases with non-fluorinated pol-ymers such as poly propylene.
Processing aids (Formulation Type 3)	Use ERC emission scenario no.6b for 'use of reactive processing aid at industrial site (no inclusion into or onto article' 0.1% w.w to air 5% w.w to wastewater and 0.03% w.w to soil.	Assumption: As with the other stages there is very limited emission moni-toring data. However, feedback from one stakeholder identifies the use of processing aids in the production of construction products where the pro-cessing aid is captured within closed systems and re-used. Justification: based on the feedback from industry stakeholders the emis-sions to air in particular look broadly in line with feedback provided. The estimates for wastewater may be an overestimate and should be consid-ered a conservative worst-case.

Table 9. Overview of estimated yearly EEA emissions for 2020 (baseline) during product manufacturing (= formulation) for articles, processing aids and commercial construction mixtures.

Group	Articles	Processing aids (use in manufacturing)	Commercial construction mixtures
PTFE (granular)	188	n.a[1]	5
EFTE	97	n.a	3
PVDF	23.9	n.a	0.6
All other fluoropolymer substances	12.4	n.a	0.39
All non-polymeric PFAS substances	185	5.0	88

1: n.a. not applicable

4.6 Emissions product use

In Table 10 the assumptions used to calcalute the emissions during product use are given. Aditionally, the justifications for these assumptions are given. In Table 11 the emissions are presented.

Table 10. Key assumptions and justifications for calculation of emissions during product use.

Component	Value	Assumption and Justification
Application Proportional splits for articles and commercial construction mixtures.	Assume in lieu of better data a 50:50 split between outdoor and indoor applications for both articles and commercial construction mixtures.	Assumption: No data available to help guide. Have assumed an even split to remain neutral. Justification: see above.
Application assumes emission factors for commercial construction mixtures outdoors.	Use ERC emission scenario no. 9b for 'widespread use of functional fluid (outdoor)' 5% w.w to air 5% w.w to water and 5% w.w to soil.	Assumption: The application of mixtures may cover a very wide range of activities with varying potential for release to air, land, and water. In lieu of more data have assumed the most appropriate ERC default factors. Justification: Given the likely wide variation in specific activities these ERC factors represent the best estimate.
Application assumes emission factors for commercial construction mixtures indoors.	Use ERC emission scenario no. 9a for 'widespread use of functional fluid (indoors)' 5% w.w to air 5% w.w to wastewater and Emissions to soil not applicable.	Assumption: The application of mix-tures may cover a very wide range of activities with varying potential for release to air, and wastewater. In lieu of more data have assumed the most appropriate ERC default factors. Justification: Given the likely wide variation in specific activities these ERC factors represent the best esti-mate.
In-use phase, outdoor applications. Emission factors.	Use ERC emission scenario no. 10a for 'widespread use of articles with low release (outdoors)' 0.05% w.w to air 3.2% w.w to water and 3.2% to soil	Assumption: Both fluoropolymers and non-polymeric PFAS substances are known to be hard wearing and highly stable to forms of degradation. During the use phase outdoors the primary pathways for emission will be weath-ering and abrasion from physical /mechanical activities. However, emissions could be expected to be low overall warranting the ERC 10a emission factors. Justification: The level of weathering and emissions is likely to vary de-pending on specific PFAS substance, application, and climate. In lieu of specific data the default values pro-vide a high-level estimate.
In-use phase, indoor applications. Emission factors.	Use ERC emission scenario no.11a for 'widespread use of articles with low release (indoors)' 0.05% w.w to air 0.05% w.w to wastewater and Emissions to soil not applicable.	Assumption: As with outdoor applications, the hard-wearing nature of fluoropolymers and non-polymeric PFAS should mean low emissions overall. Primary processes for indoor environments will be contamination of dust through contact with treated surfaces and abrasion through physical /mechanical forces. Justification: see same justification for outdoor environments.
Waste	Assume quantities to reach wastewater treatment plants based on preceding steps. Assume all articles made from or containing PFAS not emitted during earlier life-cycle stages enter waste. It is possible that surfaces covered with PFAS based coatings enter the waste cycle (e.g., during repair or demolition), however, the majority of coatings are likely to remain in place with new coats painted on top of old. Therefore, without the necessary data to calculate how much of the coating enters waste it is assumed surface coatings do not enter the waste stage.	Assumption: This final stage builds upon the preceding steps to quantify materials entering waste. No further estimates are provided for emissions during the waste cycle. Justification. Assumed waste pro-cesses based on the logical flow of material

Table 11. Overview of estimated yearly EEA emissions for 2020 (baseline) during use of articles and commercial construction mixtures. For processing aids no emissions are expected.

Group	Articles		Commercial construction mixtures		
	In-use (outdoors) All vectors (tonnes)	In-use (indoors) All vectors (tonnes)	Application All vectors (tonnes)	In-use (outdoors) All vectors (tonnes)	In-use (indoors) All vectors (tonnes)
PTFE (Granular)	117	1	19.96	5	0.04
EFTE	71	1	11.97	3	0.03
PVDF	16	0.1	2.69	0.7	0.01
All other fluoropolymer substances	7.5	0.1	1.25	0.35	0.01
All non-polymeric PFAS substances	110	1	334	91.25	0.75

5. Exposure (workers, consumers)

Below information is given on the potential exposure of workers and consumers to PFAS.

5.1 Workers

- 16 companies provided data in the CfE or the targeted consultation (all in confidential attachments to the CfE or in confidential input to the consultation protected under non-disclosure agreements that allow only use in aggregated figures) on the number of workers employed in the production and handling of well over 100 different PFAS-based construction products. The sum of these workers for all products of the 16 companies amounts to approximately 12,000 workers (rounded to closest 1,000). The construction sector as a whole employs some 18 million people in the EU.[9]
- Considering the uncertainty of the estimate of the overall market for PFAS in construction products and given that many of the stakeholders who provided their number of workers did not specify the related tonnage of PFAS in construction products, extrapolation to the whole market has not been deemed appropriate based on the available data. The construction sector as a whole employs some 18 million people in the EU. Given the diverse uses of PFAS in construction products, it stands to reason that the share of construction workers that handle PFAS-based products at least occasionally is not insignificant.
- Articles: exposure during production of articles could occur through inhalation of vapours or generation of dusts from mechanical manipulation of materials. Feedback from industry stated that many product plants would make use of abatement equipment to manage both vapours and dust (how many plants and which abatement equipment was not further specified).
- Processing aids: the feedback from industry was that these processes are largely automated and use closed systems to capture and re-use PFAS as far as possible. It is possible to envisage there will be some atmospheric releases and worker exposure, particularly during maintenance windows, but overall exposure could be expected to be low.

[9] https://ec.europa.eu/growth/sectors/construction_en

- Paints and surface coatings: it can be expected that PFAS will be introduced to mixtures additively during blending and mixing. These processes are more likely to be at elevated temperature, with generation of vapours. Industry feedback was keen to highlight that fluoropolymers such as PTFE, EFTE and PVDF are highly stable with low vapour pressure, but note that also non-polymeric PFAS are used in paints and coatings.
- The highest worker exposure will likely occur during the application phase of paints and coatings (and potentially adhesives). PFAS based mixtures can be added as coatings/impregnation by spraying, rolling, or brushing onto finished articles, this may occur both indoors and/or outdoors.

5.2 Consumers

- Most construction products are not generally used by consumers.
- Uses that are more likely for consumers include DIY (Do-It-Yourself) sealant and adhesive products, DIY durable water repellent (DWR) impregnation and aftermarket floor protection (and potentially paint), however it was not possible to estimate the number of consumers using these products. It is possible that PFAS-based mixtures are to be used within DIY adhesives and sealants, but likely within small quantities.
- The greater potential for release and exposure may occur where articles are abraided during use (i.e., moving parts) or where maintenance involves cutting (fluoropolymers (such as PTFE, EFTE, and PVDF) are largely stable from degradation, while non-polymeric PFAS may be bound within the matrix of the article). Even for paints and coatings containing PFAS the major risk of exposure comes during application.
- There is a potential for release into drinking water for any applications involving liners, sealants, or coatings for water pipes.
- A significant share of all consumers will likely come into contact with buildings that have been constructed using PFAS-based construction products. However, if undisturbed and not subject to direct weathering or washing, the potential release is likely low. Even for paints and coatings containing PFAS the major risk of exposure comes during application, which given the specialist nature of PFAS containing paints is more likely to affect professional workers. The emission estimates for indoor use of paints and coatings are relatively low (4 tonnes per annum from the 3,848 tonnes of PFAS (both polymeric and non-polymeric con-sumed in paints and coatings across the EEA).

5.3 Indirect exposure of humans via the environment

- Providing further comment on the potential human exposure to PFAS via the environment from uses in construction products (including paints and coatings) is extremely challenging.
- It is possible for major construction projects this could include outdoor uses on sites near water or agricultural land.
- The estimated wastewater emissions from the formulation stage have a high potential to end up in sewage sludge, which is applied to agricultural land in some (but not all) EEA states. This would likely give rise to the potential for contamination of food.

6. General discussion on emissions and exposure

Existing legal requirements:

No specific information is given on existing legal requirements.

Effectivenes of operational conditions and risk management measures:

No information is given on this subject.

7. Alternatives

Very limited data was provided on alternatives for the construction products (both articles and surface coatings) through the CfE. The dossier from POPRC (The Persistent Organic Pollutants Review Committee)[10] has been used alongside the Annex XV dossier for PFHxS and PFHxA and a brief literature search to supplement the CfE responses further. The alternatives for PFAS in articles, and paint and coatings are given in Table 12 and Table 13, respectively.

[10] Draft report on the assessment of alternatives to PFOS, its salts and PFOSF (UNEP/POPS/POPRC.14/INF/8)

Table 12. Alternatives for construction products – articles.

Subuse/ Function	PFAS	Non PFAS alternative?	Advantage / disadvantage	Costs
Thermal insulation applications	n.s.[1]	Options such as: • Polyisocyanurate • Phenolic thermal product	• High technical feasibility • Specific applications may require different solutions	n.s.
Processing aids in the production of construction products	n.s./ confi-dential	Confidential	• Each has trade-offs in performance • Either lack of chemical stability and flame retardancy or (see column 'costs')	Not economically feasible or (see column 'advantage/ disadvantage')
Architecturial fabrics	Fluoro-polymers	Cotton and other natural fibres	• Low technical performance • Feasible for light-duty applications	n.s.
		Polyamid (nylon)	• High strength, stifness and tenacity • Low weight • Not dimensionally stable when wet • Poor UV resistance • Stretches considerably	
		Polyester	• Good tensile strength and elasticity • Mechanical properties degrade with UV light • Subject to ageing • Can be coated with PVC to provide UV protection	
		Fiberglass	• High tensile strength (although decreasing when wet) • Long lifetime • Brittle • Low elastic strain • Can be coated with silicone to enhance properties (not further specified)	
		Aramid (Kevlar, Twaron)	• High strength (except compressie strength) • Low weight • Good abrasion/chemical/thermal resistance • Can degrade from UV exposure • Can be coated with PVC or silicone to provide UV protection	
		Carbon fibres	• Used (usable) for high-tech products • Low expansion coefficient • Non-combustible	
Fluoropolymer tube lining	Fluoro-polymers	Polypropylene	• Chemical resistance approaches fluoropolymer • Comparable low surface friction, corossion resistance, dielectric strength and low weight • *For all substitute materials the possibilities depend on the performance requirements of the specific application*	Less costly
		Silicone	• Temperature resistance	
		PVC	• Chemical resistance	
		Co-extrusions (two different materials are extruded as the inner and outer layers)	n.s.	

1: n.s. not specified

Table 13. Alternatives for construction products – paints and coatings.

Subuse/Function	PFAS	Non PFAS alternative	Advantage / disadvantage	Costs
Paints and coatings	Polymeric and non-polymeric PFAS[1]	• Polyurethane • Polyester powder • Wax emulsions • Silicones/silanes/polysiloxanes • Hydrocarbon polymer technologies	• Technical feasibility and availability not provided	n.s.
	Polymeric and non-polymeric PFAS[1]	Hydrocarbon and silicone-based surfactants	• Do not provide the same performance in terms of reducing surface tension, oil and dirt repellency. • It is necessary to use higher concentrations within the paint mixture compared to fluorosurfactants	n.s.
		Short chain, polyether-modified siloxanes	• Reduces static surface tension • Almost universal aids for difficult to wet and contaminated substrates in diverse areas of application including on capillary substrates such as wood • Ability to customize properties such as compatibility, low foam and anti-cratering effects via polyether modification and siloxane chain length.	
		Low molecular weight polyether-modified siloxanes	• Reduces the surface tension in waterborne systems more strongly than hydrocarbon-based surfactants or higher molecular weight polyether siloxanes • Anti-cratering properties • Can be used to improve wetting of wood substrates • Can be used in spray paints • Provides optimum atomization during application without affecting the slip characteristics of the dried finish	
		Siloxane multi-functional surfactants	• Combination of reduction in surface tension and defoaming properties • Imparting good recoat properties	
		Alkoxylates (silicone and solvent-free)	• Reduce dynamic surface tension which is particularly advantageous for printing inks (potentially less relevant in the context of construction products) • Foam inhibiting and degassing in waterborne coatings and printing inks • Can be used to act as a deaerator and to wet pigments and promote flow	
	PFOS[2] PFHxS	Fatty alcohol polyglycol ether sulphate (sometimes together with a sulfosuccinate)	• n.s.	n.s.
Superhydrophobic coatings	n.s.	Polymeric matrix (the binder) added to hydrophobic nanoparticles (the filler)	• Can be used to address the challenge of optimising mechanical durability, as the rough asperities required for maintaining super-hydrophobicity otherwise tend to be easily removed by abrasion • This technology still appears to be in development • Its performance is not specifically compared to that of PFAS coatings	
Wood primer and inks	PFOS[2]	Sulfosuccinates (e.g. sodium salt of di-(2-ethylhexyl) sulfosuccinate	• Dissolved in ethanol and water already used as alternative • Di-(2-ethylhexyl) sulfosuccinate can also be used as an alternative mixed with silicone polymers, ethanol and water	n.s.
Rust protection systems, marine paints, resins, printing inks and coatings in electrical applications	PFOS[2]	• Propylated napthalenes • Propylated biphenyls	• Can be used as water repelling agents	n.s.

1: n.s. not specified

2: Note that PFOS and its derivatives is listed in Annex I part A of the POP-regulation, https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:02019R1021-20210315

8. Economic impacts in case of a full PFAS ban

Below the economic, environmental, social and other impacts of a full PFAS ban are described based on the Call for Evidence and targeted stakeholder consultation.

8.1 Economic impacts

- Many stakeholders did not provide cost estimates for substitution but instead suggested that no alternatives were available and/or that reformulation was not possible in their view.
- Some highlighted that a lack of alternatives that can provide a similar combination of properties would potentially require significant changes to applications in the construction sector, but further detail on the affected products and associated costs could not be provided.
- No specific input was received to provide a separate estimate for technical and organisational costs for developing and implementing alternatives
- In many cases, PFAS are used in construction products to improve durability and reduce maintenance/cleaning. If this functionality is lost/reduced, this would lead to higher maintenance costs, as well as costs and waste associated with more frequent replacement.
- It appears likely that a restriction on the use of PFAS in construction products would lead to a significant loss of business for certain suppliers and therefore potential closures of particularly effected businesses. However, no information was available to quantify the loss of business.
- A potential loss of competitiveness of the European construction product industry.
- Substitution costs and time required for identification of alternatives, reformulation, obtaining market qualifications could not be quantified at this stage but could be substantial.

8.2 Environmental impacts

- Substition of processing aids will not match its performance in terms of being “circular economy ready”, durability, environmental footprint per quantity installed and disposed of, cost effectiveness and vapour permeability, according to a producer.
- Performance benefits will be lost, such as energy savings due to translucency, durability, fire resistance, reduced structural building materials due to light weight, UV resistance, and novel architectural designs.

8.3 Social impacts

- Stakeholder input was received from some suppliers of construction products dependent on PFAS, employing some 1,000 people in sum, of which at least a share if expected to be lost. It was also suggested that job losses “in the thousands” could occur in the wider construction industry, although no further detail was provided as to how and why this employment would be lost. Note that generally speaking, a share of any employment losses would likely be temporary, but sufficient information was not available to judge the time of the employment losses and any potential salary implications.

8.4 Other impacts

- Potential health and safety implications in the applications seals/bearings and pipe linings.

- One producer indicated that fundamental research is required to find alternatives for processing aids that deliver the required performance and are subject to lower environmental concerns than PFAS.

9. Uncertainties

The uncertainties of the presented information are given here per section.

9.1 Substances uses and applications

- Some substances identified in literature have not been identified by stakeholders (and vice-versa), so there is some uncertainty about whether these are (still) used in the EEA in reality.
- There are probably further PFAS substances used that have not been identified. This could be the case particularly for substances (and their uses) that are considered commercially sensitive and strictly confidential.
- Relatively little specific information on degradation products has been received and a comprehensive literature review on potential degradation of each of the identified substances used has not been performed.

9.2 Manufacturing (market data + market price)

<u>Market data</u>

The market data gathered via the CfE is incomplete and structured in a fashion that makes analysis very challenging. As an example, two key issues can be highlighted:

- Respondents have provided data identifying which PFAS are in use, and further data on specific named products including working concentrations for PFAS. However, it is possible for the same product to be used across multiple specific activities and even across major sectors (e.g., the same product may be used in construction and mining). Total quantities manufactured and imported has been provided by some respondents but as a headline number without disaggregation by use. This means it is not possible to apportion tonnages to uses even at the parent level.
- Many respondents have provided data as ranges and in some cases these ranges are very broad (e.g., "<1,000 tonnes" = 1 – 999 tonnes). Standard approaches can be applied to help us calculate quantities, but with many respondents using large ranges the estimates would be very uncertain.

Market data from the CfE and the targeted stakeholder consultation likely does not cover all relevant users, and sufficient information to extrapolate from the stakeholders that provided information (e.g., their market share) to the whole EEA market was not available. The market data from stakeholder consultation may also include some double counting (when different supply chain stages report tonnages for the same products), although this is likely less severe than the previous caveat.

For construction products, sufficient data was not available to provide a breakdown of tonnages of PFAS used by sub-use or application.

A further uncertainty is associated with the definition of a 'lubricant use'. PFAS can be used for providing smooth and frictionless surfaces. Whether such applications shall be seen as lubricant use or coating/sealing use will impact the figures of PFAS in both lubricants and construction.

<u>Number of production sites</u>

No specific information was given on the number of production sites. However, some information was presented on the number of workers of the 16 companies which provided data in the CfE or the targeted consultation (12,000 workers). This number is uncertain and should therefore be considered only a rough indication of the number of magnitude of workers involved with the products of those 16 companies.

Tonnages

REACH database

It should be noted that official statistics on production and trade (e.g., Eurostat Prodcom or Comext data) are not sufficiently detailed to identify PFAS-based construction products. As polymers are exempt from registration under REACH, and a lot of PFAS-based construction products are based on polymeric PFAS, tonnage bands from ECHA's database of registered substances are also not useful in this case. Additionally, the CfE identifies approximately 20 non-polymeric PFAS substances in use, but with no tonnage data provided. This makes further analysis challenging.

SPIN database

There are certain limitations in using data from the SPIN database to estimate tonnages of PFAS used:

- The database is based on data from the Product Registries of Norway, Sweden, Denmark and Finland and there are certain limitations to what needs to be notified[11] which means that not all construction products (containing PFAS) will be notified. In addition, confidential information may not be included in the market figures derived from the SPIN database.
- Tonnage estimates from the SPIN database are extrapolated from the participating countries to the EEA as a whole, based on the assumption that PFAS use in construction products per capita is the same across the EEA.

Information from stakeholder consultation

There are certain limitations and uncertainties related to the provided information by the stakeholders on manufacturing and import of PFAS:

- The data provided through the CfE and supplemented by further stakeholder input likely does not cover all relevant users.
- The data gathered via the CfE is incomplete and structured in a fashion that makes analysis very challenging. Respondents have provided data identifying which PFAS are in use, and further data on specific named products including working concentrations for PFAS. However, it is possible for the same product to be used across multiple specific activities and even across major sectors (e.g. the same product may be used in construction and mining). Total quantities manufactured and imported has been provided by some respondents but as a headline number without disaggregation by use. This means it is not possible to apportion tonnages to uses even at the parent level.
- The figures may include some double counting (when different supply chain stages report tonnages for the same products).
- Many respondents have provided data as ranges and in some cases these ranges are very broad (e.g. "<1,000 tonnes" = 1 – 999 tonnes). Where data has been provided as ranges, the upper bounds have been used to quantify a 'worst case' scenario, but with many respondents using large ranges the estimates are very uncertain.

[11] For instance, Part 3 of the Executive Order setting out the notification duties for the Danish Product Registry (https://at.dk/en/regulations/executive-orders/special-duties-suppliers-1794/).

- In general, no specific information on import and export of PFAS-based construction products was identified.

9.3 Emissions

- The approach uses a basic source-flow model, which involves some degree of simplification and generalisation of the life-cycles of the different products.
- A very large number of substances have been identified as being in use or potentially in use (with varying quality of data available on each), so the approach taken has not tried to develop estimates on a substance-by-substance basis, but grouped the main substances used and types of uses (based on emission-relevant considerations such as way of application of PFAS to product, indoor/outdoor use, professional/consumer use, etc.).
- Specific data on releases was not available for all substances, products and life-cycle stages. Assumptions based on expert judgement and Environmental Release Category (ERC) emission scenarios have been used to fill the gaps.
- In addition, the uncertainties around market data (see above) cascade into the emission estimates.
- Therefore, the estimates included in this section should be treated as indicative orders of magnitude and not definitive estimates to the nearest tonne.

9.4 Exposure to workers and consumers

- Similar uncertainties as for the market data (see above) apply to the use of information from the CfE on workers associated with PFAS-based construction products.
- In addition, downstream user sectors and applications are very wide-ranging and diverse. Any estimates provided should therefore be considered only a rough indication of the number of magnitude of workers/users involved.

9.5 Alternatives

- For alternatives to PFAS in construction products, very limited data was provided from stakeholder consultation, and the input received regarding alternatives stems exclusively from industry.
- Literature on potential alternatives has been identified for some of the main applications but is not comprehensive.

9.6 Economic impacts in case of a full PFAS ban

- Information on the main types of costs was patchy covering only some of the many applications of PFAS in construction products. Hence, it is not clear whether they apply to PFAS-based construction products in general, although it seems likely that the general conclusions outlined above are probably similarly applicable across most applications
- All stakeholder responses received related to economic impacts came from industry and so the results reflect exclusively an industry position.
- One major source for uncertainty is whether current assets could be used or if they would need to be replaced (which could cost in the order of hundreds of millions of Euros).