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Potential SVHC in environment and articles – information collection with the aim to prepare restriction proposals for PFAS

Final report

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Potential SVHC in environment and articles – information collection with the aim to prepare restriction proposals for PFAS

Final report

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Abstract: Potential SVHC in environment and articles – information collection with the aim to prepare restriction proposals for PFAS

The report covers main findings of two information collection activities that have been performed with the aim to collect basic information to be able to assess risks that originate from per- and polyfluorinated compounds. The information collections were performed to support the preparation of Annex XV Dossiers to initiate restrictions under REACH. The work covered in particular long-chain perfluoroalkyl carboxylic acids (long-chain PFCA) and short-chain per- and polyfluorinated alkylated substances (short-chain PFAS). Also included were the salts of the two groups, precursor substances and substances, such as polymers, that contain these substances as structural element. Information were collected via literature research, IT-based surveys and targeted interviews with stakeholders.

Furthermore, the report contains some general considerations on the use of IT–based surveys in the context of information collections in regulatory activities under REACH.

Kurzbeschreibung: Potential SVHC in environment and articles – information collection with the aim to prepare restriction proposals for PFAS

Der Bericht umfasst die Kernergebnisse zweier Informationssammlungen, die es ermöglichen sollten Risiken zu beurteilen die von per- und polyfluorierten Chemikalien (PFC) ausgehen können. Ziel dieser Recherchen war es, die Arbeiten an Anhang XV Dossiers zu unterstützen, um Beschränkungen im Rahmen von REACH anzustoßen. Die Arbeiten umfassten konkret Informationserhebungen zu den langkettigen perfluorierten alkylierten Carboxylsäuren (engl. long-chain perfluoroalkyl carboxylic acids – long-chain PFCA) sowie den kurzkettigen per- und polyfluorinierten alkylierten Stoffen (short-chain per- and polyfluorinated alkylated substances – short-chain PFAS). Eingeschlossen in die Datenerhebung waren zudem die Salze der beiden Stoffgruppen, Vorläuferstoffe sowie Stoffe, die diese Stoffe als strukturelle Elemente enthalten (z.B. Polymere). Die Informationen wurden über Literaturstudien, IT-gestützte Umfragen sowie gezielte Interviews mit Interessensvertretern erhoben.

Des Weiteren enthält der Bericht auch grundsätzliche Überlegungen zum Nutzen IT-gestützter Umfragen in Informationserhebungen im Rahmen regulatorischer Aktivitäten unter REACH.

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(AR) AFFF	(Alcohol resistant) Aqueous film forming foams
6:2 diPAP	bis(3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl) hydrogen phosphate
6:2 FTOH	3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctan-1-ol
6:2 FTS	3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctane-1-sulfonic acid (6:2 fluorotelomer sulfonate)
6:2 monoPAP	3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl dihydrogen phosphate
8:2 FTOH	3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,10-heptadecafluorodecan-1-ol
BASE	Bielefeld Academic Search Engine
diPAP	polyfluoroalkyl phosphoric acid diester
DU	Downstream User
ECHA	European Chemicals Agency
EPA	Environmental Protection Agency
EU	European Union
FCM	Food contact materials

FMAs	Fluorotelomer methyl acrylates
FPs	Fluoropolymers
FTAB	Fluorotelomer sulphonamide alkylbetaine
FTAs	Fluorinated acrylpolymers
FTB	Fluoro telomer betaine
FTIs	Fluorotelomer iodides
FTOHs	Fluorotelomer alcohols
FTS	Fluortelomer sulfonate
FTSAS	Faluorotelomer mercaptoalkylamido sulfonate
IMAP	Inventory Multi-tiered Assessment and Prioritisation
KEMI	Swedish chemicals agency (Kemikalieinspektionen)
LC PFAS	Long Chain PFAS
LOD	limit of detection
LOQ	level of quantification
MeFBSA	N-(Methyl)nonafluorobutanesulfonamide
MeFBSAC	2-[methyl[(nona-fluorobutyl)-sulphonyl]amino]ethyl acrylate
MeFBSE	N-methyl-perflurobutane sulfonamido ethanol
NGO	Non-Governmental Organisation
NICNAS	National Industrial Chemicals Notification and Assessment Scheme
NORAP	Nordic Risk Assessment Project
OECD	Organisation for Economic Co-operation and Development
PAG	photo-acid generator
PAPs	Polyfluoroalkyl phosphate esters
PASF	Perfluoroalkane sulfonyl fluoride
PBSF	1,1,2,2,3,3,4,4,4-nonafluorobutane-1-sulfonyl fluoride
PBT	persistent, bioaccumulative and toxic
PCBs	printed circuit boards
PFAA	perfluoroalkyl acids
PFAS	Per- and polyfluorinated alkylated substances
PFBA	2,2,3,3,4,4,4-Heptafluorobutanoic acid (C_4-PFCA)
PFBS	1,1,2,2,3,3,4,4,4-nonafluorobutane-1-sulfonic acid (C4-PFSA)
PFCA	perfluoroalkyl carboxylic acids
PFCs	per- and polyfluorinated chemicals
PFDA	Nonadecafluorodecanoic acid (C10-PFCA)
PFDS	Perfluorodecane sulfonate

PFDoDA	Tricosafluorododecanoic acid (C12-PFCA)
PFHnPA	1,1,2,2,3,3,4,4,5,5,6,6,6-tridecafluorohexyl phosphonic acid
PFHpA	2,2,3,3,4,4,5,5,6,6,7,7-dodecafluoroheptanoic acid (C_7-PFCA)
PFHpS	1-Heptanesulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6,7,7,7-pentadecafluoro-, potassium salt
PFHxA	2,2,3,3,4,4,5,5,6,6,6-undecafluorohexanoic acid (C_6-PFCA)
PFHxS	1,1,2,2,3,3,4,4,5,5,6,6,6-tridecafluorohexane-1-sulfonic acid (C6-PFSA)
PFNA	Perfluorononan-1-oic acid (C9-PFCA)
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctane sulfonic acid
PFPA	perfluoro alkyl phosphonic acid
PFPeA	2,2,3,3,4,4,5,5,5-nonafluoropentanoic acid (C_5-PFCA)
PFPeS	1,1,2,2,3,3,4,4,5,5,5-undecafluoropentane-1-sulfonic acid (C_5-PFSA)
PFPiA	Perfluoro alkyl phophinic acid
PFSAs	perfluoroalkane sulfonic acids
PFTeDA	Heptacosafluorotetradecanoic acid (C14-PFCA)
PFTrDA	Pentacosafluorotridecanoic acid (C13-PFCA)
PFUnDA	Henicosafluoroundecanoic acid (C11-PFCA)
POP	Persistent organic pollutants
PPE	personal protective equipment
PTFE	Poly tetra fluoro ethene
PVDF	poly vinyliden fluoride
PVDF	polyvinylidene fluoride
R&D	Research and Development
RMM	risk management measures
RMOA	Risk Management Option Analysis
SAM	self-assembled monolayers
SC PFAS	Short-chain PFAS
SPIN	substances in preparations in the Nordic countries database
TOF	total organic fluorine
tpa	Tons per year
UBA	German Environment Agency (DE Umweltbundesamt)
vpvb	very persistent and very bioaccumulative
WWTP	waste water treatment plant

Summary

The EU chemicals legislation REACH (Regulation (EC) No. 1907/2006) on one hand has the aim to collect relevant data on chemical substances and, on the other hand, defines processes, with the aim to minimise risks that originate from chemicals for human health and/or the environment as far as possible or to eliminate them, completely. One of the REACH instruments in order to realise this is the restriction procedure. Within this measure, far reaching substance restrictions that cover the entire EU-area can be introduced. To justify such a far reaching intervention on the single market, the authorities of member states or the EU have the obligation to collect extensive data on products and processes to identify potential sources of the exposure on individuals and/or the environment and to evaluate the proportionality of a measure (e.g. a ban) in regard of the consequences for the market actors.

A substance group of particular relevance for the environment are the per- and polyfluorinated alkylated substances (PFAS). PFAS contain multiple Fluorine-Carbon bondages, which are one the strongest chemical bondages that exist. The consequence of this bond is a high stability of these chemicals in technical processes that are performed under ridged process conditions (e.g. high temperature, acids etc.). Therefore, these substances are interesting for application of all kind of applications such as surface treatments of goods with high mechanical stress. Examples of such applications are water and dirt repellence of membranes for outdoor textile or anti-stick surfaces in cooking goods.

At the same time this stability poses hazards for the environment and living beings, including humans. If PFAS are released into the environment, they cannot be degraded again by natural pathways. In addition to this, it is proven that some of the substances tend to accumulate in food chains or disperse in water bodies and can reach drinking water reservoirs from there. Furthermore, since for some of the compounds toxic effects have been demonstrated, there have been activities in the EU and other regions of the world to limit the release representatives of the PFAS group and to ban them in national, regional or even global legislation frameworks.

PROJECT AIMS

In the frame of the project basically three aims were realised:

- In order to prepare a restriction proposal on perfluoroalkyl carboxylic acids (PFCA) with carbon chain lengths from C9-C14 information were collected in the years 2016-17, that dealt with the way and extend of the substance use. The information collection covered the substances themselves, but also their salts, so called precursor substances as well as substances derived from PFCA such as polymeric compounds. Deviating from the original project, planning the information collection was extended to PFCA with chain lengths up to C20. In the frame of this report in summary the term long-chain PFCA is used.
- In the second part of the project (2017-18) a comparable information collection was performed for PFAS with shorter carbon chains (mainly those with C4 or C6 chain lengths). In this case, also other substance groups apart from carboxylic acids were explicitly addressed, such as acrylates, iodides or sulphur compounds. Again, also salts, precursors and derived compounds such as polymers were included. Analogous to the long-chain PFCA in this context the term short-chain PFAS is used. In this case, there was also the intention to evaluate the need for a restriction under REACH. Hence, the aim was to collect and document the available information, to be able to evaluate the overall situation of the substance group

or to be able to identify potential information gaps. In this working package, the same methods were applied as for the long-chain PFCA.

- The third and overreaching aim was the development of a model approach for situations were information collection is intended to be initiated in the frame of regulatory processes from chemical substances. It was the intention in the frame of this part, to develop a questionnaire with standard question, which can be used for such activities. The main focus of this part was the development of an approach that can be used for IT-based surveys.

METHODS

To be able to perform a broad information collection, various elements were combined in the project. Following methods were applied:

- Two literature studies were performed
- Organisation and execution of two IT-based surveys, to collect data from stakeholders
- Targeted interviews with market actors, associations or NGOs to collect additional details and to clarify potential open questions that resulted from the IT-based surveys.

On basis of the two surveys on the different substance groups a collection of standard questions was developed that can be used for the development of future surveys.

MAIN RESULTS

In the following the main results of the three working areas are presented briefly.

Long-chain PFCA

A main finding of the information collection on the long-chain PFCA was, that no direct or indirect uses of these substances could be identified. This means that none of the involved market actors could confirm the use of one of the PFCA as such in a process. Furthermore, also polymeric substances (e.g. polymers with fluorinated side chains ending in PFCA) were not used. The application of PFNA as emulsifier in the manufacture of elastomers was identified via literature search but none of the contacted manufacturers of such elastomers confirmed that use is in place. It can be stated that there is some uncertainty whether or not PFNA is used by other elastomer manufacturers place fluoroelastomers on the EU market that were manufactured with PFNA and who did not contribute to the information collection.

Generally, the collected information indicate that the main source of long-chain PFCA has been their presence as impurity in other fluorinated substances in the past. This refers mainly to their presence in PFOA and in PFHxA. These eight respectively six chained compounds are manufactured in a process of C2 chain elongation reaction. Besides the intended products C6 and C8, relevant amounts of C4 are manufactured as well as longer chains such as C10, C12, C14. Since the elongation is an addition of C2, no chains occur with uneven chain lengths. As a result of the EU-wide restriction of PFOA, market actors have started to remove all C8 compounds from the manufacture process of shorter chain substances (C4, C6) as far as possible. A side effect of this purification procedure was that also long-chains were removed to the same extend as PFOA. Therefore, it can be expected, that these substances become irrelevant as impurities, the latest in 2020 at the time the PFOA restriction is fully taking effect.

Short-chain PFAS

In contrary to the long-chain PFCA, short-chain PFAS were identified in numerous applications. Mostly, they are present as side chains of polymers to form fluorotelomers, which are used in the surface treatment of various materials such as textiles, paper, and leather, to mediate water and dirt repellence properties. Besides that, short-chained PFAS find their way into mixtures that are used as surface-active agents. These are, as the most important group among others, firefighting foams, but also surface active mixtures in the production of semiconductors, traditional photography or x-ray photography and the use in coating, glues or inks in non-food applications.

Direct uses of the substances covered, besides the use as monomer for side-chain fluorinated polymers, is their use as intermediates. This covers the transformation of various short-chain substances groups (e.g. acrylates, iodides, carboxylic acids) into each other or the use as building blocks for the manufacture of substances (which are not fluorotelomers). In addition, the use as a processing aid (emulsifier) in the production of fluoropolymers was reported.

The substitution potential of short-chain PFAS is evaluated as problematic or even impossible, on a general level. Partly, it was acknowledged, that there are in principle alternatives for many of the applications. Partly, they are even placed on the market by the same suppliers or used in parallel to the fluorine containing product, but are considered to mediate less performance. For some areas, a substitution is not excluded per se, but is considered to cause a high economic burden of single market actors, with the result that the time horizon of a substitution could rather be realised on midterm (about 10 years), realistically. Such a time frame is needed, to test suited alternative substances and initiate a pre-commercial development. For single companies a restriction would result in a complete new orientation on the market as over 90 % of the turnover are currently depending on short-chain PFAS.

For firefighting foams technical limits are claimed in regard to a substitution of PFAS. Manufacturers and associations from this sector have doubts that alternatives meet essential performance requirements when it comes to large liquid fires (e.g. fuel depot fires). Currently aqueous film forming foams (AFFF) are used, where these actors consider the use of PFAS as absolutely necessary.

In another area, where a substitution of short-chain PFAS would result in major technical problems, in the view of involved parties, would be the area of semi-conductors. In this sector comparably small amounts of short-chain PFAS are used under comparable closed conditions in the production of semi-conductors. They are used in a number of production steps (application of the photo-resist, generation of the photo-acid during etching). There are currently no alternative substances known for these steps that mediate the same properties as short-chain PFAS do. In this case any substitution activity would first result in a scientific research project (especially because of the fundamental different use in this area compared to the other uses presented before). Involved companies and associations request an exemption if a restriction would be issued in the future based on the low amount and the high level of enclosure of the substances in this area.

Another important aspect regarding the substitution in almost all sectors that were involved (with partly exemption of the semi-conductor industry) was, that short-chain PFAS have been introduced as a substitute for PFOA (also for PFOS), which have been regulated in the past years, first at EU, then increasingly at global level in the frame of the Stockholm Convention. As a result of this, a re-assessment and adaptation of the product portfolio and processes after such is seen critical by many market actors.

Furthermore, short-chain PFAS are evaluated to be less problematic by many stakeholders as there are studies that indicate they have a lower bioaccumulation potential and that the toxicity is also lower compared to PFOA and PFOS. On the other hand, there were actors that claimed that persistence alone poses a significant problem and that the potential to bioaccumulate in fact is lower, but at a price of higher mobility in the environment. This, in their view, might result in a higher chronic background exposure of living beings, in particular via drinking water. Resulting from this consideration these actors welcomed additional regulation of short-chain PFAS. Others in turn refused such measures as a matter of principle and referred to the improved risk management in regard to fluorinated substances that has been implemented as a reaction on the restrictions already implemented.

General approach on information collection

The basis for this working package were the two IT-based surveys, which were executed in the context of the long-chain PFCA and the short-chain PFAS. A main feature of these surveys, content wise, was that the survey covered a wide range of different substances (substances on their own, their salts, precursors and derived substances). Resulting from this certain consequences followed for the design of the questionnaires and the interlink between various information areas. It was e.g. necessary to establish links between the substance identity and its tonnage and the information on uses which are linked to the substances (e.g. conditions of use, established risk management, or the emissions) or the economic effects that might result from a ban of that substance.

At the same time, it should be easy for the user of the questionnaires to complete them, e.g. by selecting an information from predefined answer options. In particular, this was a problem to define for which substances information should be retrieved. While the fluorinated substances in total form a large group and a high number of users have limited knowledge on the chemistry of the group, the identification task could not be made easier by predefining substance names or identification numbers (CAS, EC), to provide a selection for the user and to provide a clear identification by doing so. Such an approach could not be realised within the frame of the survey. If there are any cases in the future, that address one or only few substances, such an approach could be implemented in addition.

The survey was realised via an open source tool (Lime Survey) in an online version and has been hosted by an external service provider. Stakeholders had to register themselves, in order to retrieve questions used for the information collection and that were adapted to their role. For some companies the online submission of information posed a high barrier to submit product related and economic data, since this was not covered by the common rules for data security of their organisation. In such cases other pathways for data submission were selected. This problem could not be solved in the frame of this study, but should be addressed in the future if data is requested.

On the basis of the experiences made in the two surveys a collection of questions has been generated, that can be used in future information collections according to restriction proposals. This collection is shown in the appendix to this report.

Zusammenfassung

Die EU-Chemikalienverordnung REACH (Verordnung EC Nr. 1907/2006) dient zum einen der Erhebung relevanter Daten zu chemischen Stoffen, zum anderen definiert sie Prozesse, die zur Aufgabe haben, Risiken, die von Chemikalien für die menschliche Gesundheit und/oder die Umwelt bestehen, zu minimieren oder nach Möglichkeit gänzlich zu beseitigen. Eines der REACH-Instrumente ist das Verfahren der Beschränkung. Im Rahmen dieser Maßnahme können weitreichende Stoffverbote für den gesamten EU-Raum erlassen werden. Um einen solch tiefgreifenden Eingriff in den gemeinsamen Binnenmarkt zu rechtfertigen, ist es Aufgabe der Behörden der Mitgliedsstaaten oder der EU, umfassende Daten zu Produkten und Verfahren zu sammeln, Quellen für eine mögliche Exposition von Personen und/oder der Umwelt zu identifizieren, sowie die Angemessenheit einer Maßnahme (z. B. eines Verbots) in Hinblick auf die Konsequenzen für die Marktakteure zu bewerten.

Eine Stoffgruppe von besonderer Relevanz für die Umwelt sind per- und polyfluorierte Chemikalien (PFC oder PFAS für englische Bezeichnung per- and polyfluorinated alkylated substances). PFAS enthalten zahlreiche Fluor-Kohlenstoff-Bindungen, welche zu den stabilsten chemischen Bindungen zählt. Konsequenz dieser Bindung ist eine hohe Stabilität dieser Chemikalien in technischen Prozessen unter widrigen Prozessbedingungen (hohe Temperatur, Säuren etc.) und macht sie daher Interessant für Anwendungen aller Art, wie z. B. Beschichtungen von Gegenständen mit hoher Beanspruchung. Beispiele für solche Anwendungen sind wasser- und schmutzabweisende Membranen in Outdoortextilien oder Anti-Haftbeschichtungen von Kochgeschirr.

Gleichzeitig birgt diese Stabilität aber auch Gefahren für Umwelt und Lebewesen, inklusive des Menschen. Werden PFAS in die Umwelt freigesetzt, können sie auf natürlichem Wege nicht wieder abgebaut werden. Zudem reichern sich einige der Verbindungen erwiesenermaßen in Nahrungsketten an oder breiten sich in Wasserkörpern aus und können auf diesem Wege auch das Trinkwasser erreichen. Da für einige der Stoffe auch bereits toxische Effekte nachgewiesen wurden, gibt es bereits seit einiger Zeit Bestrebungen in der EU und anderen Regionen der Welt die Freisetzung relevanter Vertreter der PFAS zu unterbinden und diese, wenn möglich, im Rahmen nationaler, regionaler oder auch globaler Rechtssetzung zu verbieten.

ZIELSETZUNGEN DES PROJEKTS

In Rahmen des Vorhabens sollten drei wesentliche Ziele realisiert werden:

- Im Rahmen der Vorbereitung eines Beschränkungsvorhabens zu perfluorierten Carboxylsäuren (PFCA) mit den Kohlenstoffkettenlängen C9-C14, wurden im Jahr 2016-17 Informationen zu Art und Umfang der Nutzung dieser Stoffe erhoben. Dabei sollten sowohl deren Salze, als auch sogenannte Vorläuferstoffe, sowie von den PFCA abgeleitete Stoffe, wie z. B. polymere Verbindungen erfasst werden. Die Recherche wurde, abweichend von der ursprünglichen Vorhabenplanung, auf PFCA mit einer Kettenlänge von bis zu einschließlich C20 erweitert. Zusammenfassend wird im Bericht von langkettigen PFCA gesprochen.
- Im zweiten Teil des Vorhabens (2017-18) sollte eine vergleichbare Informationserhebung für PFAS durchgeführt werden, die kürzere Kohlenstoffkettenlängen besitzen (im Wesentlichen solche mit den Kettenlängen C4 und C6). Dabei wurden außer den Carboxylsäuren auch andere Stoffgruppen explizit eingeschlossen, wie z. B. Acrylate, Iodides oder auch Schwefelverbindungen. Auch hier sollten sowohl die Salze, als auch Vorläuferstoffe, sowie abgeleitete Verbindungen, wie Polymere, mitberücksichtigt werden.

Analog zu den langkettigen PFCA wird in diesem Zusammenhang auch von den kurzkettigen PFAS gesprochen. In diesem Fall sollte ebenfalls eine Bewertung erfolgen, ob eine Beschränkung im Rahmen von REACH notwendig sein könnte. Ziel dieser Erhebung war daher zunächst die verfügbaren Informationen zu sammeln und so aufzubereiten, dass eine Bewertung der Situation für diese Stoffgruppe möglich wird, bzw. potentielle Informationslücken identifiziert werden können. Dabei kamen die gleichen Methoden zur Anwendung, die bereits für die C9-C14 PFCA angewendet wurden.

- Drittes übergeordnetes Ziel war die Entwicklung eines modellhaften Vorgehens, für Situationen bei denen Informationen für chemische Stoffe in regulativen Verfahren erhoben werden sollen. Dabei sollte ein Fragebogen mit Standardfragen entwickelt werden, der für solche Vorhaben angewendet werden kann. Der Fokus lag hier insbesondere auf der Entwicklung eines Ansatzes, der IT-gestützte Umfragen umfasst.

VORGEHEN

Um eine möglichst umfassende Informationserhebung durchführen zu können wurden verschiedene Elemente im Rahmen des Vorhabens miteinander kombiniert. Folgende Methoden kamen dabei zur Anwendung:

- Durchführung von zwei Literaturstudien
- Organisation und Durchführung von zwei IT-gestützten Umfragen, um Daten von den verschiedenen Interessensvertretern zu erfragen
- Gezielte Interviews mit einzelnen Marktakteuren, Verbänden oder NGOs zur Erhebung zusätzlicher Details und Klärung möglicherweise bestehender offener Fragen, die sich aus der IT-gestützten Umfrage ergeben haben

Anhand der beiden Umfragen zu den verschiedenen Stoffgruppen wurde ein Katalog mit standardfragen entwickelt, der Grundlage für die Entwicklung weiterer Umfragen darstellen kann.

ZENTRALE ERGEBNISSE

Nachfolgen werden kurz die zentralen Ergebnisse der einzelnen Arbeitsbereiche dargestellt.

Langkettige PFCA

Zentrales Ergebnis der Informationserhebung zu den langkettigen PFCA war, dass keine direkten oder indirekten Verwendungen dieser Stoffe identifiziert werden konnten. Dies bedeutet, keiner der involvierten Marktakteure konnte bestätigen, dass in einem Verfahren einer diese PFCA als solcher eingesetzt wird und auch polymere Verbindungen (z. B. Polymere mit fluorierten Seitenketten) kommen nicht zum Einsatz. Eine Anwendung von PFNA als Emulgator von Fluorelastomeren konnte in der Literatur identifiziert werden. In Nachfragen bei Herstellern solcher Elastomere konnte dessen Verwendung jedoch nicht bestätigt werden. Hier besteht eine gewisse Restunsicherheit über die Nutzung von PFNA, da es durchaus Elastomerhersteller geben könnte die mit PFNA Fluorelastomere auf den EU-Markt bringen könnten und nicht an der Informationserhebung teilgenommen haben.

Im Wesentlichen legen die gesammelten Informationen nahe, dass die Hauptquelle von langkettigen PFCS in der Vergangenheit ihre Anwesenheit als Verunreinigung in anderen fluorierten Stoffen war. Im Wesentlichen sind hier das PFOA sowie das PFHxA zu nennen. Diese acht- bzw. sechskettigen Verbindungen werden über eine C2 Kettenverlängerungsreaktion hergestellt. Dabei entstehen neben den gewünschten C6 und C8 ketten auch relevante Anteile C4 sowie längere Ketten, wie C10, C12 oder C14. Da die Reaktion über die Verlängerung eines C2 erfolgt, entstehen keine Ketten mit ungeraden Kettenlängen. Durch das EU-weite Verbot des PFOA, haben die Marktakteure begonnen alle C8 Verbindungen aus der Herstellung der kürzerkettigen Stoffe (C4, C6) möglichst gut zu entfernen. Als Nebeneffekt dieser Reinigung wurden in gleichem Umfang auch Ketten entfernt, die länger waren als die des PFOA, sodass erwartbar ist, dass spätestens mit dem Inkrafttreten des PFOA Verbots in 2020 auch diese Stoffe keine Rolle als Verunreinigung mehr spielen.

Kurzkettige PFAS

Im Gegensatz zu den langkettigen PFCA wurden für die kurzkettigen PFAS zahlreiche Anwendungen gefunden. Zumeist werden sie dabei als Seitenketten von fluorierten Polymeren verarbeitet und kommen dann als Beschichtung verschiedenster Materialien, wie Textilien, Papier, Leder, zum Einsatz, um diesen sowohl wasser- als auch fettabweisende Eigenschaften zu vermitteln. Daneben finden kurzkettige PFAS ihren weg in Gemische, in denen sie als oberflächenaktive Verbindungen genutzt werden. Dazu gehören, als wichtigste Gruppe, Feuerlöschschäume, aber auch oberflächenaktive Gemische bei der Herstellung von Halbleitern, klassischer Fotografie oder Röntgenfotografie, sowie der Einsatz in Anstrichstoffen, Klebern oder Tinten im Non-Food Bereich.

Direkte Anwendungen der Stoffe umfassten, neben der Anwendung als Monomer für die Fluortelomere, ihre Nutzung als Zwischenprodukt. Dabei werden die verschiedenen kurzkettigen Stoffgruppen (z. B. Acrylate, Iodide, Carboxylsäuren) entweder ineinander umgewandelt oder zu Stoffen, bei denen sie als Baustein zum Einsatz kommen (und die nicht zur Gruppe der Fluortelomere gehören). Auch als Prozesshilfsstoffe (Emulgator) in der Produktion bestimmter Fluorpolymere kommen kurzkettige PFAS zum Einsatz.

Insgesamt wird das Substitutionspotenzial der kurzkettigen PFAS problematisch bis derzeit unmöglich eingeschätzt. Zum Teil wird zwar anerkannt, dass in vielen der genannten Anwendungen grundsätzlich Alternativen bestehen. Sie werden sogar teilweise von den gleichen Anbietern vertrieben oder parallel zu den fluorhaltigen Produkten verwendet, werden aber vielfach weniger leistungsfähig erachtet. Zum Teil wird eine Substitution nicht ausgeschlossen, würde jedoch zu einer relativ hohen wirtschaftlichen Belastung einzelner Marktakteure führen, sodass eine Umstellung eher mittelfristig (ca. 10 Jahre) realistisch erscheint. Dieser Zeitraum wird benötigt, um geeignete Ersatzstoffe zu erproben und dann entsprechend zu einer marktreife zu führen. Für einzelne Unternehmen würde ein Verbot der Stoffe jedoch auch eine komplette wirtschaftliche Neuausrichtung bedeuten, da > 90% des Umsatzes auf Produkte entfallen, die von den kurzkettigen PFAS abhängen.

Technische Grenzen der Substitution werden vor allem für die Nutzung von PFAS in Feuerlöschschäumen geltend gemacht. Hier zweifeln Hersteller und Verbände aus dem Bereich an, dass Ersatzstoffe die entsprechende Leistungsfähigkeit besitzen, wenn es um das Löschen großer Feuer in Verbindung mit brennbaren Flüssigkeiten geht (also z. B. Tanklagerbrände). Hier kommen wasserfilmbildende Schäume (AFFF) zum Einsatz, bei denen PFAS als zwingend notwendig angesehen werden.

Ein anderes Gebiet, für welches die Substitution kurzkettiger PFAS nach Aussagen Beteiligter, große technische Schwierigkeiten mit sich brächte, ist die Halbleiterindustrie. Hier werden vergleichbar geringe Mengen kurzkettiger PFAS unter relativ geschlossenen Anwendungsbedingungen in der Produktion von Halbleitern verwendet. Dort spielen sie in verschiedenen Teilschritten eine Rolle (Aufbringen des Fotolacks, Generierung der

„photographischen Säure“ im Ätzprozess). In diesen Schritten sind derzeit keine alternativen Stoffe bekannt, die entsprechende Eigenschaften vermitteln, wie dies die kurzkettigen PFAS tun und hier würde eine Substitution mit einer vorgeschalteten Grundlagenforschung einhergehen (vor allem aufgrund der vergleichbar anderen Nutzung im Vergleich zu Anwendung im Bereich zuvor genannter Anwendungen). Die beteiligten Unternehmen und Verbände forderten daher und aufgrund der hohen Gefasstheit und der geringen verwendeten Mengen, dass die Verwendung der Stoffe in diesem Bereich ausgenommen sein sollte.

Wichtiger Aspekt bei der Substitution in nahezu allen Branchen (mit Ausnahme z. T. der Halbleiterindustrie) ist, dass die kurzkettigen PFAS bereits das Substitut für das PFOA (oder ggf. auch das PFOS) darstellen, welche in den zurückliegenden Jahren zunächst auf der EU-Ebene reguliert wurden und die zunehmend auch in den Fokus globaler Regelungen im Rahmen des Stockholmer Übereinkommens kommen. Daher wird von zahlreichen Marktakteuren eine erneute Anpassung des Produktportfolios und der Prozesse besonders kritisch gesehen.

Zudem werden die kurzkettigen PFAS von zahlreichen Stakeholdern als weniger problematisch angesehen, da es Studien gibt die nahelegen, dass sie ein geringeres Bioakkumulationspotenzial besitzen und auch ihre Toxizität geringer ist als bei PFOA und PFOS. Andererseits gab es auch Akteure die äußerten, dass die Persistenz als solches ein signifikantes Problem darstelle und dass zwar ein geringeres Bioakkumulationspotenzial bestünde, dieses jedoch zulasten der Mobilität in der Umwelt ginge, wodurch höhere chronische Hintergrundbelastungen von Lebewesen, vor allem durch die Belastung im Trinkwasser in Kauf genommen würden. Daraus haben diese Akteure geschlossen, dass grundsätzlich weitergehende Regelungen für kurzkettige PFAS zu begrüßen seien. Andere Akteure lehnten dieses grundsätzlich ab und verwiesen auf das deutlich verbesserte Risikomanagement in Bezug auf fluorierte Chemikalien, welches sich durch die bereits etablierten Beschränkungen weiter verbessert habe.

Allgemeines Vorgehen zu Informationserhebungen

Basis dieses Arbeitspakets waren die beiden IT gestützten Umfragen, die im Zusammenhang mit den langkettigen PFCA bzw. den kurzkettigen PFAS durchgeführt wurden. Wesentliches inhaltliches Kennzeichen dieser Erhebung war, dass die Befragung sich auf eine große Anzahl verschiedener Stoffe erstreckt hat (die Stoffe selber, ihre Salze, Vorläufer und abgeleitete Stoffe). Daraus resultierten ganz bestimmte Anforderungen an die Gestaltung der Fragebögen und die Verknüpfung der einzelnen Informationsbereiche. Es musste z. B. sichergestellt werden, dass Informationen zur Stoffidentität und einer Tonnage verknüpft werden können, mit Information zu Verwendungen (z. B. den Anwendungsbedingungen, dem etablierten Risikomanagement oder den Emissionen), die sich auf diesen Stoff beziehen oder auch die ökonomischen Effekte, die sich aus dem Verbot dieses Stoffes ergeben. Gleichzeitig sollte es der Nutzerin oder dem Nutzer der Fragebögen leicht gemacht werden diese auszufüllen, z. B. durch ankreuzen zutreffender Informationen, die vorgegeben wurden. Besonders problematisch war dies bei der Frage, für welchen der Stoffe Informationen erhoben werden sollten. Obschon die fluorierten Stoffe insgesamt eine große Gruppe darstellen, bei der zahlreiche Nutzer der Stoffe über eine geringere Expertise hinsichtlich der Chemie der Gruppe besitzen, konnte die Eingabe der Stoffe nicht dadurch erleichtert werden, indem konkrete Stoffnamen oder Identifikationsnummern (CAS, EC) vorgegeben wurden, aus denen der Nutzende auswählen konnte und so seine Stoffe klar identifizieren konnte. Ein solches Vorgehen hätte den Rahmen eines Fragebogens gesprengt. In anderen konkreteren Fällen, bei denen eher einige wenige Stoffe eine Rolle spielen, können solche Vorgaben implementiert werden.

Die Umfragen wurden anhand eines open source Programms (Lime Survey) online erstellt und durch einen Drittanbieter gehostet. Hier mussten sich Stakeholder anmelden, um dann, entsprechend ihrer Rolle angepasst, Fragen zu erhalten, die für die Informationssammlung genutzt wurden. Für einige Unternehmen stellte die Online Übermittlung von Informationen zu produktbezogenen und ökonomischen Daten eine Hürde dar, da diese Vorgehen nicht von den üblichen Vorgaben der Organisationen zur Datensicherheit gedeckt waren. In solchen Fällen wurden z. T. andere Wege der Informationsübermittlung gewählt. Dieses Problem war im Rahmen der Studie nicht zu beheben, sollte aber berücksichtigt werden, wenn Daten erhoben werden sollen.

Auf Basis der Erfahrungen der beiden Umfragen, wurde dann ein Katalog von Fragen zusammengestellt, der künftig die Grundlage darstellen kann, weitere Informationserhebungen im Rahmen von Beschränkungsvorhaben zu initiieren. Dieser Katalog ist im Anhang dieses Berichts einzusehen.

1 Background of the report

Per- and polyfluoroalkyl substances (PFAS), are ubiquitously found both in humans and the environment. Concerns have been identified due to their persistent, bioaccumulative and toxic properties (PBT). This has led increasingly to risk reduction measures initiated by authorities and certain companies. Perfluorooctane sulfonic acid (PFOS) was the first substance that was regulated across the EU via a restriction in the frame of the REACH-regulation[1]. Later the substance was also regulated on a global level via the Stockholm Convention. It was therefore deleted from REACH and shifted to the implementing legislation of this convention in the EU, the so called POP-Regulation[2]. The second substance that was regulated under REACH was the perfluorooctanoic acid (PFOA). A restriction proposal was submitted to the European Chemicals Agency (ECHA) by the member states Germany and Norway in 2014. The EU Commission decided to restrict the substance in 2017.[3] As a reaction to these restriction activities, a shift in the production and use towards PFAS with shorter chains as alternatives was observed. Similar to long-chain PFAS, short-chain PFAS are used in a wide dispersive way. The chemicals are distributed in the environment ubiquitously due to their mobility. Currently short-chain PFAS are already increasingly detected in different environmental media, in remote places and drinking water resources. Therefore, it is relevant to illustrate possible concerns and adverse effects related to their presence in different environmental compartments in order to initiate regulatory measures, where needed. Furthermore, there was uncertainty on the fact if PFAS with longer chain lengths than the ones of PFOA are also intentionally used. These substances were also detected in environmental samples, which triggered an investigation of these substances in more detail.

The German Environment Agency (Umweltbundesamt – UBA) as an assessment unit for the evaluation of environmental risks, started to investigate specific PFAS representatives in more detail. In 2016 the UBA prepared a Risk Management Option Analysis (RMOA) on long-chain PFAS (more specific perfluoroalkyl carboxylic acids (PFCA) with C chain lengths from C9 to C14 (see Table 1) in cooperation with Swedish competent authorities which concluded that a restriction would be the most appropriate measure to target potential risk that might originate from these substances.

Table 1: The perfluoroalkyl carboxylic acids (C9-C14 PFCA) (source UBA/KEMI 2016 RMOA[4])

Substance name	Acronym	CAS-Number	EC-Number
Perfluorononan-1-oic acid (C_9-PFCA)	PFNA	375-95-1	206-801-3
Nonadecafluorodecanoic acid (C_{10}-PFCA)	PFDA	335-76-2	206-400-3

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

[2] Regulation (EC) No 850/2004 of the European Parliament and of the Council of 29 April 2004 on **p**ersistent **o**rganic **p**ollutants and amending Directive 79/117/EEC (POP = **p**ersistent **o**rganic **p**ollutants)

[3] Commission Regulation (EU) 2017/1000 of 13 June 2017 amending Annex XVII to Regulation (EC) No 1907/2006 of the European Parliament and of the Council concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) as regards perfluorooctanoic acid (PFOA), its salts and PFOA-related substances http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32017R1000

[4] See outcome document of RMOA from Website of the German REACH-CLP-Biocide Helpdesk https://www.reach-clp-biozid-helpdesk.de/SharedDocs/Downloads/DE/REACH/Verfahren/RMOA-Conclusions/REACH-RMOA-PFHxA-Conclusion.pdf?__blob=publicationFile&v=6 and in the ECHA Public activities coordination tool (PACT) https://echa.europa.eu/de/rmoa/-/dislist/substance/100.005.641

Substance name	Acronym	CAS-Number	EC-Number
Henicosafluoroundecanoic acid (C_{11}-PFCA)	PFUnDA	2058-94-8	218-165-4
Tricosafluorododecanoic acid (C_{12}-PFCA)	PFDoDA	307-55-1	206-203-2
Pentacosafluorotridecanoic acid (C_{13}-PFCA)	PFTrDA	72629-94-8	276-745-2
Heptacosafluorotetradecanoic acid (C_{14}-PFCA)	PFTeDA	376-06-7	206-803-4

Further investigations initiated by the UBA covered potential concerns that might arise from the use and emissions of short-chain PFAS. Short-chain PFAS in this regard are

- PFCA with chain lengths < 7 perfluorinated C-atoms or
- Per- and polyfluorinated sulfonic acids with < 6 perfluorinated C-atoms

Short-chain PFAS can also originate from various other chemical groups. Some examples are given below (not conclusive):

- The salts of the above mentioned substances
- Substances that have the potential to degrade to PFCA or PFSAs, i.e. precursors, such as perfluoroalkane sulfonyl fluoride (PASF)- and fluorotelomer-based compounds, e.g.:
  - Fluorotelomer alcohols (FTOH)
  - Fluorotelomer iodides (FTI)
  - Fluorotelomer acrylates (FTA) and fluorotelomer methyl acrylates (FTMA)
- polymeric PFAS such as
  - "*Fluoropolymers: fluorinated polymers consisting of carbon-only backbone with fluorines directly attached to this backbone (e.g. polytetrafluoroethylene or PTFE; polyvinylidene fluoride or PVDF; fluorinated ethylene propylene or FEP; perfluoroalkoxyl polymer or PFA; etc.). Fluoropolymers are not made from PFCA or their potential precursors (except that perfluorobutylethlyene (PFBE) can be used as a comonomer). PFCA homologues are, however, used as processing aids in the polymerization of some fluoropolymers.*
  - *Side-chain fluorinated polymers: fluorinated polymers consisting of variable compositions of non-fluorinated carbon backbones with polyfluoroalkyl (and possibly perfluoroalkyl) side chains. The fluorinated side-chains, including PASF- and fluorotelomer-based derivatives, are potential precursors of PFCA.*
  - *Perfluoropolyethers: fluorinated polymers consisting of backbones containing carbon and oxygen with fluorines directly attached to carbon. They are not made from PFCA or their potential precursors; and PFCA or their potential precursors are not involved in the manufacturing of perfluoropolyethers. …" (OECD 2013[5])*

[5] https://www.oecd.org/env/ehs/risk-management/PFC_FINAL-Web.pdf

In the framework of these reports all these substances will be covered under the term short-chain PFAS unless something different is explicitly stated in the text. The term PFAS covers short-chain PFAS as well as LC PFAS. The term PFC is not used (unless used in literature assessed or by stakeholders themselves to qualify the use of fluorinated substances in an unspecific way).

All substances from these groups, except the precursor substances, are highly persistent. With decreasing chain lengths, the substances become increasingly water soluble. Therefore, there was an initial concern that these substances might pollute water bodies relevant for the generation of drinking water and in conclusion pose a similar risk as the longer chained variants of the PFAS (for further details see also Brendel et al. 2018)[6].

To be able to prepare a restriction proposal, the submitting authority has to prepare a dossier based on Annex XV of REACH[7]. In this dossier, the authorities need to describe which substances are covered by the intended restriction and which uses and/or products might pose a risk that needs EU wide measures.

In case of the PFAS the large variety of different substances, precursor or substances derived from a particular compound that can be subsumed under the group of PFAS (e.g. polymers that include a substance as a building block) poses a large challenge when a restriction proposal is under development. The chemical names of the substances, tonnages and areas of uses are not publically available for a large part of the substance group representatives. The uses and products which they are part of are also not known or only to a limited extend. Furthermore, the information that needs to be provided in an Annex XV dossier covers the availability of alternatives to the use of fluorinated compounds and the socio-economic impacts of a potential restriction scenario for the various areas of application.

It should be highlighted that the information provided is necessary to define the scope of the restriction. This also includes:

- The identification of uses, materials or final products where adequate/acceptable control can be assumed. Such applications can be excluded from the scope of the restriction proposal.
- Furthermore, exemptions can be included in the restriction proposal if these can be justified, e.g. if the lack of viable alternatives or a high socio-economic relevance of the area of application can be demonstrated.
- Information on the extend of the use, the content of the substances concerned in products and the socio-economic impact of a planned “non-use” scenario helps to define potential limit values for a later verification of the later restriction.

In the case of PFAS these data are systematically missing due to a number of reasons:

1. Only few lower molecular PFAS are manufactured and placed on the market as such in tonnages that would require full registration under REACH.
2. In many cases one PFAS is chemically transferred into another one and has therefore a status as intermediate, which would not require a full registration dossier and no chemical safety report (CSR).

[6] Brendel et al. (2018) Short-chain perfluoroalkyl acids: environmental concerns and a regulatory strategy under REACH, Full text at Springer website https://enveurope.springeropen.com/articles/10.1186/s12302-018-0134-4

[7] See also Article 60 (4) of REACH in combination with Annex XVII.

3. The lower molecular PFAS are often used as building blocks for polymeric substances that do not require a registration. Therefore, there is no risk assessment of these subsequent indirect uses foreseen and no information on use areas is provided to the authorities.
4. In some applications only limited amounts of PFAS are needed (e.g. the use of PFAS as polymerization aids in the manufacture of fluoropolymers). These do not require any registration or they require only the minimum data set (without CSR which would provide more information on the risk control in the particular use).

Information on business impacts of proposed restrictions, potential alternatives and ingoing parameters for risk assessments (amount and concentration of substances in processes and products, use conditions and risk management measures (RMM)) is typically held by industry stakeholders that manufacture, import and use these substances. The Annex XV dossiers depend to a large extend on this information from industry stakeholders. However, this target group usually has a very low motivation to collaborate actively in such processes since the outcome of a restriction proposal usually leads to the need to change the current business practice. The main motivation to cooperate with authorities is to influence the scope of a restriction proposal in a way that the restriction conditions are beneficial for them (thresholds discussion, exempted uses or products etc.).

Furthermore, it can be observed that the number of public consultations has increased over the last years. These consultations are a part in various standard processes in the course of official REACH processes like, e.g. SVHC identification, applications for authorisation and later in the restriction process when the official draft is discussed.

To overcome this lack of information the UBA decided to generate this information prior to the official announcement of its intention to prepare Annex XV dossiers for the LC PFCA and the short-chain PFAS. In the frame of a research project the UBA contracted two external consultants, Ökopol (Germany) in cooperation with RISE IVF[8] (Sweden) to initiate a data collection on specific representatives of PFAS. The following tasks were part of the service provided:

- Preparation of two literature searches,
- the organisation and execution of two IT based surveys to collect data form stakeholders,
- Focused interviews to generate additional information and clarify open questions that might originate from previous data collections.

Another overreaching research topic was the investigation to which extend IT based surveys can be helpful to assist information collection in the frame of data collection in the preparation of Annex XV dossiers. One additional outcome of this overreaching activity was the derivation of a more general questionnaire to be used in similar information collections, based on the learning experiences made on the PFAS.

This report gives an overview on the work executed in the years 2016-19. The first phase of the work on the LC PFCA was performed from 2016-17. The information generated fed into the preparation of a restriction proposal submitted in 2017. Final opinions of the committees for risk assessment (RAC) and socio-economic analysis (SEAC) have been adopted in November 2018 recommending a restriction for these substances. A draft restriction proposal and decision by the EU-Commission and the involved Committee on REACH and CLP is pending[9]. In the

[8] Formerly Swerea IVF

[9] Status as of March 07th 2019, see https://echa.europa.eu/registry-of-restriction-intentions/-/dislist/details/0b0236e18195edb3

second phase of the project, from 2017-19, an information collection was performed on the short-chain PFAS. In December 2018 Germany submitted an intention to develop a restriction proposal for Undecafluorohexanoic acid including its salts and related substances (PFHxA, CAS no: 307-24-4)[10].

[10] https://echa.europa.eu/registry-of-restriction-intentions/-/dislist/details/0b0236e18323a25d

2 Phase 1: Information collection "long-chain PFAS "

Phase 1 of the project comprised an information collection for LC PFCA with chain lengths > C8. The original scope of the survey was to collect data on LC PFCA with chain lengths of C9-C14 (five substances). This scope was extended by another five substances (C15-20) on request of the EU-Commission[11]. So the scope of the information collection covered all LC PFCA with chain lengths from C9 – C20. The EU-Commission intended to make use of this data to prepare a document to be submitted in the frame of the identification procedure for substances under the Stockholm Convention on the global regulation of Persistent Organic Pollutants (POP). These twelve PFCA substances were therefore seen as the "core group" (see Table 2). It was also the intention of the UBA to include the salts of the substances, the so-called precursor substances and substances that use representatives of the core group as building blocks for other substances (derived substances), as well as alternatives that could be used to substitute fluorinated compounds in the respective applications.

Table 2: „Core group" of substances during first project phase

Abbreviation	Name	Synonym	CAS.-No.
PFNA	Perfluorononan-1-oic acid	C9-PFCA	375-95-1
PFDA	Nonadecafluorodecanoic acid	C10-PFCA	335-76-2
PFUnDA	Henicosafluoroundecanoic acid	C11-PFCA	2058-94-8
PFDoDA	Tricosafluorododecanoic acid	C12-PFCA	307-55-1
PFTrDA	Pentacosafluorotridecanoic acid	C13-PFCA	72629-94-8
PFTeDA	Heptacosafluorotetradecanoic acid	C14-PFCA	376-06-7
PFPeDA	Nonacosafluoropentadecanoic acid	C15-PFCA	141074-63-7
PFHxDA	Hentriacontafluorohexadecanoic acid	C16-PFCA	67905-19-5
PFHpDA	Perfluoroheptadecanoic acid	C17-PFCA	57475-95-3
PFODA	Pentatriacontafluorooctadecanoic acid	C18-PFCA	16517-11-6
PFNDA	Perfluorononadecanoic acid	C19-PFCA	133921-38-7
-	Perfluoroeicosanoic acid	C20-PFCA	68310-12-3

Following steps were performed to collect information:

- A literature study,
- An IT based online survey,
- A series of (telephone) interviews

The results of these activities are shown in the following chapters. Data submitted during this collection of information are shown in an aggregated and anonymised way only. Details on the way the IT based survey was performed is shown in Chapter 4 ff. of this report. Chapter 2 documents the main findings from the project phase 1.

11 This request was not a formal process, but rather informal.

2.1 Literature study on C9-C14 PFCA “Publicly available sources and overviews on production and application for PFAS”

2.1.1 Literature search in scientific publications

A main aim of this part of the study is to provide a mapping of applications of PFAS with perfluorinated chain lengths of C9 to C14 to understand potential sources of these chemicals in the environment.[12] In order to prepare a first overview, scientific articles were retrieved via the database science direct (Scopus) and via the Bielefeld academic search engine (BASE); the latter is a meta-search engine for web-based documents, which links to digital archives and digital libraries all over the world, for example CiteseerX at the Pennsylvania State University or the Swedish-Norwegian Diva portal. BASE includes open access sources and documents that are considered as “grey literature” and cannot be found in science direct, including among other reports published by authorities and dissertation theses.

An initial screening search in early 2017 was carried out in Scopus to map the existing state of research and identify which areas of research contribute. The search with the keyword “perfluorinated” brought a total of 6,400 hits. Most publications (3,300) are listed in the subject area “chemistry” with “material science” second (1,700) and “environmental science” third (1,300). The attribution to a subject area is non-exclusive. The majority of scientific publications for “perfluorinated” and the subject area “environmental science” focuses on observation of compounds in different environmental compartments and in biota. Potential health effects and analytical aspects are addressed. For the PFCA with a per-fluorinated carbon chain length between 9 and 14 the numbers are: PFNA 170 results; PFDA 125 results; PFUnA 30 results; PFDoDA 22 results; PFTrDA 5 results and PFTeDA 3 results. The initial search also showed 8 results for PFDS, perfluorodecane sulfonate.

Publications in the subject area chemistry focus on progress in the development of advanced materials such as membranes, nanomaterials or graphene; those are currently produced in lab scale and not available in large scale production. Therefore, this cannot be used to identify sources of PFAS which can already be found in the environment today. From this initial search it can be concluded that sources and applications in products are usually not addressed in publications, the focus is rather on observation of the substances in the environment. This applies for samples taken in remote areas, for which no emitters can be identified. For samples in industrial areas locations are not disclosed and no production volumes and specifications are provided, meaning that a direct cause-effect-relationship cannot be established.

To complement data on production and applications, reports provided for environmental authorities are to be used as relevant repositories. A starting point are documents provided for the Stockholm Convention on persistent organic pollutants which provide a global perspective. Additionally, a report for per- and polyfluorinated substances in the Nordic countries included a mapping of uses. The data collection included for that case a combination of interviews and queries from public lists.

2.1.2 Publicly available information for producers of fluorochemicals in a global perspective

Some fluorochemicals producing companies are organized in FluoroCouncil, a global industry council for fluorotechnology administered by the American Chemistry Council. Membership is voluntary and not a requirement for industry activities in the field. The group members and

[12] Further details on this research activity are presented in Appendix A

group size change over the course of time. In 2019 the organisation's website lists a total of seven members: Asahi glass co., Ltd. (AGC) based in Tokyo; Daikin Industries Ltd. based in Osaka; Solvay specialty polymers based in Brussels, and Chemours, based in Wilmington/USA. Archroma management LLC based in Reinach/Switzerland and Singapore, Dynax Corporation located in Pound Ridge/USA and Tyco/Johnson Control located in Milwaukee/USA and Cork. Arkema group based in Colombes/France was a member in the past but is no longer listed. No member company is headquartered in China. The number of fluorochemicals producing companies worldwide is much bigger. FluoroCouncil submitted in the beginning of 2014 to UNEP (the Stockholm convention) a list of potential producers of PFAS which are not members. The list contains 108 entries for four regions. More than half of the entries are for China with 55 entries. Other regions are Asia (ex-China) with 11 entries, Europe with 27 entries and North America with 15 entries. The companies 3M and DIC are listed twice, one entry referring to the European activity and another to activities in North America (3M) and Japan (DIC).[13]

This list includes product categories and names with varying level of details. Some entries list general information such as "fluoro surfactants" for various purposes, others include brand names. The list includes also resellers. Applications mentioned in the list include firefighting foams, paper water proofing agents, ski wax, fluoropolymers and flouroelastomers. Among the specific chemical species listed are PFOS, PFOA, PFOSF, PFBS, PFHxA. No homologues with longer perfluorinated chains are listed explicitly. As the list contains information collected by the FluoroCouncil on non-member companies, the information provided is considered as uncertain and incomplete. No information is given for production capacities and volumes, and among the listed companies are also resellers and distributors, but the respective role is not explicitly made clear in the list.

2.1.3 Publicly available information for fluorochemicals in a Nordic European perspective

The following section reiterates procedure and findings from previous mapping projects carried out in Sweden, Norway and Denmark in 2012 and 2013. Where available updates with current information published after 2012 are provided.

A mapping study for the Nordic region was published in 2013 (Posner et al., 2013). Interviews were conducted with more than 50 players in the Nordic European market with the aim of obtaining information on use and type of PFAS substances. The survey and interview results were not considered as complete. In parallel a net list was therefore produced of PFAS substances based on three lists as available in 2012, when the study was published: a list compiled by the OECD (Organisation for Economic Co-operation and Development (OECD, 2007[14]), an extract of PFAS substance found in the REACH pre-registration data base, and an extract of PFAS found in the database SPIN, short for Substances in Preparations in Nordic Countries. The list of pre-registered substances covers all substances that have been pre-registered in accordance with Article 23 of REACH and could be placed on the market until the final transition period of June 2018 by the specific pre-registrant, unless it exceeds a relevant tonnage[15]. Latest opportunity to pre-register a substance was twelve months before the latest deadline. The list is provisional and does not contain any company information nor does it guarantee the substance is really placed on the EU market and at which tonnage. It is still

[13] After the literature search the list was used as a basis for further investigations. The web resources were checked and a search for contact persons was performed. These contacts should be used for additional direct request for information.

[14] update 2018; ENV/JM/MONO(2018)7
http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=env/jm/mono(2018)6&doclanguage=en

[15] http://echa.europa.eu/information-on-chemicals/pre-registered-substances

available on the ECHA website and includes a number of substances for which no registration dossier has been submitted subsequently. At the time of the compilation of Posner et al. (2013), it was considered as a relevant source of information since the registration database itself did not contain many entries, and it was not known whether a registration dossier was in preparation for more substances. The SPIN database includes per- and polyfluorinated substances and polymers contained in dangerous chemical mixtures manufactured in or imported to in the Nordic countries. The data has its origin in the national product registries, which compile data directly from companies, for Sweden that is established via the Swedish Chemicals Agency (KEMI)[16]. Submission of information is mandatory for substances that are identified through their custom tariff number; above 100 kg it is also mandatory to provide information on the tonnage. The database is searchable via identifiers such as CAS number, EC number or using part of the substance name. The total use is provided for Denmark, Norway, Sweden and Finland distinguished by years, and a limited information on use is available based on use codes. In total, 27320 substances are included. For perfluorinated substances, information on volumes is in many cases listed as confidential due to the low tonnage; this has been recognised as a general issue for specialty chemicals.

A key conclusion in Posner et al. (2013) was that most production of relevant articles is outside the EU and the then current legal framework did not provide adequate means to obtain sufficient information about specific PFAS in imported articles. The compiled net list was therefore considered to be not complete and it was expected that significantly more PFAS substances were used in the Nordic market. The study found publications on occurrence and effects, but also concluded that: "…*there are considerable information gaps for most of the PFAS chemicals regarding the exact chemical composition in commercial products, their quantities produced and uses on the Nordic market. These gaps may be a combination of lack of knowledge and/or trade secrets from the actors on the Nordic market.*" (Posner et al., 2013).

Based on information gathered after 2013, a cursory update was performed on substances included in the initial list that are in the subset of long-chain PFAS. The SPIN database includes information on ammonium perfluorononane sulfonate (CAS 17202-41-4), total 4 tonnes in 2000 and 2001 in Denmark, without information on uses. An assessment by the Australian authority NICNAS also came to the conclusion that only in the Nordic countries use has been registered, but information on uses is not available. 10:2 FTOH (CAS 865-86-1) and 12:2 FTOH (39239-77-5) is also listed in SPIN, in both cases the data were contributed from Denmark and listed as confidential, thus not providing any additional information on tonnage or use.

A search for registration dossiers did not provide any additional information on use, as no registration dossier for any of the substances included in the subset of pre-registered substances. The REACH registration database covers information from the dossiers of already registered substances, also information on tonnage and whether a full or intermediate registration was applied[17]. For the current task to identify additional applications of longer chain PFAS no information could be contributed from that update.

A report by the Danish environmental agency (MST) from 2012 indicated that "…*no data have been identified on the global production and use of PFCA of chain lengths longer than C9."* (Lassen et al., 2013). PFUnA, PFDoDA, PFTrDA and PFTeDA were each identified as a substance of very high concern (SVHC) due to vPvB properties, in December 2012. Conclusions on use were based

[16] https://www.kemi.se/en/products-register/about-the-products-register - information in English

[17] https://echa.europa.eu/de/information-on-chemicals/registered-substances

on exposure and increasing concentrations in biota, no production data is provided in these contexts.

PFNA was identified as a SVHC due to PBT properties in December 2015. In this case use "*…as a processing aid for the fluoropolymer manufacture, most notably for polyvinylidene fluoride (PVDF) is listed. Additionally use as lubricating oil additive, surfactant for fire extinguishers, cleaning agent, textile antifouling finishing agent, polishing surfactant, waterproofing agents and in liquid crystal display panels has been relevant in the past. The report also highlights that no registration dossier has been submitted to the REACH database, and that the recent and future trends indicate a general transition towards shorter chain surfactants."* (ECHA, 2015).

For PFDA, previous use as plasticiser, lubricant, surfactant, wetting agent and corrosion inhibitor (has been used) is named. As with PFNA, no registration dossier has been submitted and the recent and future trends indicate a general transition towards shorter chain surfactants (ECHA, 2016).

2.1.4 Complementary information for use of fluorochemicals in products

As a potential application of perfluorinated substances, cosmetic and personal care products have been identified for which a searchable database for ingredients is provided by the European Commission, department Growth[18]. This database contains a total of more than 28,000 and 91 substances[19] of them with the keyword "perfluoro", in most cases with a short indication as regards their potential function in a product. No volumes are provided. The currentness of data is not clear, as the entire procedure of adding to and removing substances from the list is not documented.

Currently, no other branch related database providing a comprehensive overview has been identified.

2.1.5 Conclusions from the initial literature search

The class of substances addressed in the search is to an extent still seen as an "emerging topic". A majority of scientific publications addresses occurrence in the environment and rarely attempts to link observed findings to sources and emissions. Comprehensive reports state data gaps on production and use. The identification of relevant data is hampered by the use of different synonyms for single substances, the usage of "long-chain" and similar generalizing classifications.

2.1.6 Bibliography for Literature study on long-chain PFCA

ECHA, 2016. Annex XV report PROPOSAL FOR IDENTIFICATION OF A SUBSTANCE OF VERY HIGH CONCERN ON THE BASIS OF THE CRITERIA SET OUT IN REACH ARTICLE 57 1, 80.

ECHA, 2015. Annex XV report PROPOSAL FOR IDENTIFICATION OF A SUBSTANCE OF VERY HIGH CONCERN ON THE BASIS OF THE CRITERIA SET OUT IN REACH ARTICLE 57 80.

Lassen, C., Jensen, A.A., Potrykus, A., Christensen, F., Kjølholt, J., Jeppesen, C.N., Mikkelsen, S.H., Innanen, S., 2013. Survey of PFOS, PFOA and other perfluoroalkyl and polyfluoroalkyl sub- stances. Lous-review, Danish Ministry of the Environment. Environmental project 1475.

[18] https://ec.europa.eu/growth/sectors/cosmetics/cosing_en

[19] Search performed in March 2019

Organisation for Economic Cooperation and Development (OECD), 2007. Lists of PFOS, PFAS, PFOA, PFCA, related compounds and chemicals that may degrade to PFCA, ENV/JM/MONO(2006)15. https://doi.org/ENV/JM/MONO(2007)10

Posner, S., Roos, S., Brunn Poulsen, P., Jörundsdottir, H., Gunnlaugsdottir, H., Trier, X., Astrup Jensen, A., Katsogiannis, A., Herzke, D., Bonefeld-Jörgensen, E., Jönsson, C., Pedersen, G., Ghisari, M., Jensen, S., 2013. Per- and polyfluorinated substances in the Nordic Countries. https://doi.org/10.6027/TN2013-542

2.2 IT based online survey on long-chain PFCA (C9-C20)

As already described, a survey process was initiated to generate basic information that is required to prepare an Annex XV restriction proposal. In this first phase of the project the task was to generate a better data basis for the preparation of a restriction proposal under REACH for LC PFCA (see also general chapter 2 on this information collection)

The survey process itself was also divided in two parts:

a) An IT-based stakeholder survey,

b) An additional interview process to investigate more complex details and additional information.

The survey process was supposed to also cover the question, how IT-based surveys can be used efficiently in data generation for regulatory processes, such as a restriction proposal under REACH in general. This question will be discussed in an own chapter (see chapter 4) in the frame of this report. It will cover observations and conclusions that refer to both surveys performed.

The following chapter will present information on the survey organisation followed by the survey results.

2.2.1 Organisation of the survey

The survey was planned and set up in the open source survey tool “Lime Survey” hosted by an external service provider. The tool was accessible via a web interface. The survey was conducted from October 2016 until January 2017.

The objective of this survey was to increase the information basis on:

- manufactured and imported amounts of the respective substance groups
- manufactured and imported amounts of their potential alternatives
- the types of uses the substances are applied to, as well as
- the economic effects that are linked to the use of the substances

The participants had to register themselves to participate in the survey. The survey consisted of one questionnaire only. The participants had to assign the roles they covered in the supply chain at the beginning, after providing some core personal data to identify the organisation. Depending on the selected roles an individual questionnaire was generated. Similar question dependencies were also included in the individual sections of the questionnaire. In cases certain answers were given, correlating additional questions were displayed. In cases another answer was given, no follow up question was shown and the questionnaire moved forward to the next issue. Roles that were offered were:

- For substance manufacturers

- For formulators of mixtures
- For end users of substances or mixtures
- For importers of substances, mixtures or articles, as well as article assemblers in the EU (that do not apply a mixture to an article)
- For associations, NGOs or other interested third parties

The survey was divided into four question groups:

- Which substances are relevant for your organisation?
- How are processes performed in your organisation?
- What might be the economic consequences on your organisation and to what extend do you see a possibility for substitution?
- How do you in general evaluate a restriction?

2.2.2 Survey results

2.2.2.1 General observations

The feedback on the survey was very limited. Even though the survey has been announced as an official call for information via direct contact with companies and associations, as well as the ECHA, the REACH/CLP helpdesk in Germany and the UBA reach-info website, only five responses were filed.

Four answers came from individual companies and one from an association. Therefore, it was difficult to make a general evaluation of the survey approach as such. Statements on the usability of the tool were only provided by two of the companies and one association. One company (role formulator of PFCA containing products and fluorine-free alternatives) evaluated the questionnaire as well structured and the completion caused no problems. This was also reflected in the company's answers. They were clear and usable. Although, when the same company participated in a follow up event at the BAuA on the restriction of C9-C14 PFCA it became clear that the full scope of the planned restriction was not clear and that potentially additional information on other substances they are using would have been relevant as well. The other company (an end user of PFCA containing product – firefighting foam) remarked that the questions were too much producer-orientated and end users were not able to provide their specific issues with regard to the implications of the restriction. The association (same sector) echoed this point.

These comments were interpreted by the consultants as being associated with the strong data orientation of the survey (e.g. substance identities, tonnages, resulting costs of a regulation). In cases where chemical users wanted to describe more complex dependencies of supply chains, such as processes, more elaborated descriptions appeared to be necessary to provide a better understanding of the effects on a specific stakeholder. The high level of pre-defined answers reduced the possibility to include written arguments, which have to be read in detail in order to extract the relevant information. The standardisation of answers on the other hand avoided extensive political statements, instead of providing facts that can be used for risk description or in the socio-economic analysis of a restriction proposal.

The complexity of the general scope of the intended restriction could be another explanation for the very poor response. Since not only the direct use of the substances is in the scope of the restriction but also the question of impurities in other substances and precursor substances, the persons contacted could not directly identify if they would be affected by the regulation or not. This might even more be true if other persons of the organisations might need to be involved as well (e.g. product manager, procurement etc.). In order to develop a methodology for data generation in the frame of public consultations this should be considered in the future.

2.2.3 Conclusion on the survey approach

As an overall conclusion of the survey it can be stated that the complexity of the questions should be reduced when the project comes to its next stage. The instrument used has various possibilities to develop a sophisticated questionnaire structure in a short time span. Functionalities of the survey tool can be learned very fast, but it helps to have experts available when the study is designed.

A general problem of the method of using standard, quantitative surveys is the limitation of the information which can be submitted. This is even more relevant if several different items are provided (in our case many substances C9-C14 PFCA and C15-C20 PFCA as a request from the EU-Commission plus precursors and substances with impurities). This makes it very difficult to explain to the potential information providers what exactly the scope of the survey is. In the next stage it is recommended to separate subjects more clearly. An approach could be:

- One core survey on production and import of C4, C6 chemicals (only importers and manufacturers)
- One survey on polymers based on C6/C4 (fluorinated polymers, etc. which are the outcome of next literature study)
  The main advantage here seems to be that the chemistry might not be that unclear. Stakeholders might better understand the chemistry as it can be expected that many of these compounds are used intentionally and there is higher awareness of these among the stakeholders.
- One survey on sectors (paper, textiles, etc.) and for political actors (e.g. associations)

Such an arrangement might help to overcome the observed obstacle that market actors “have the feeling” not to be affected. With regard to the workload to develop these individual surveys it is assumed now (after the experience with the very complex questionnaire) that similar efforts will be needed. It is expected that in turn reduced complexity can be applied when programming the structure of the survey. Also the individual surveys should be shorter. From the experience made now, it can be a good way forward to accept that not all kind of data can be retrieved in one step with such a survey. While some information can be collected in the survey other questions might be excluded, e.g. questions regarding a more detailed process description or dependencies between the manufacture of several substances, e.g. if several substances are manufactured but not all are used in the same applications. Here the structure of a questionnaire can make it difficult to reflect these differences. Such questions can be issued in a follow up interview and be held on request by the stakeholder.

Besides the methodological problems identified, the identification of potential addressees was seen as an important issue. It is important to identify persons actually linked to the activities of the organisation with the substances. In many cases internet research does deliver very general contact information for companies. From website information it is clear that the companies do handle products that are linked to activities with the substances under consideration, but the contact information does not lead to persons that are either aware on substance issues (technical staff, research, production) nor to regulatory issues. This can result in a situation in which a specific recipient of an e-mail is not aware what to do with that information and no response is received. This might also include a pre-survey interview process to contact the companies via mail or phone to get hold of relevant persons in advance (including the direct announcement of a two stage process of the survey and an interview)[20].

2.2.4 Interview Process on C9-C14 PFCA

Following the survey, a targeted interview process was initiated. The focus was given to sectors that were assumed to use fluorinated compounds to a higher degree, but also other sectors were screened for potential relevance. The process was started with already available information based on former consultations, internet searches and assessment of databases.

Core questions that were discussed with the stakeholders are:

- Use of C9-C14 PFCA including its salts and related substances
- Tonnage of used substance (if directly used)
- Content of substance in other substances (impurities in other substances)
  - Content
  - Amount and application of contaminated substances
- Alternatives for C9-C14 PFCA
- Economic effect of a restriction (cost for substitution, loss of business/applications etc.)

The main field of the interviews covered:

- Manufacture of substances themselves or similar fluorochemicals (carried out by Ökopol)
- Manufacture of fluoropolymers, especially PVDF manufacturers (carried out by Ökopol)
- Manufacture of fluorinated polymers
  - Textile water repellents (carried out by RISE/Ökopol)
  - Paper treatment/food contact impregnation (carried out by RISE/Ökopol)
- Furniture (carried out by RISE)
- Direct uses of C9-14 PFCA and related substances
  - Firefighting foams (carried out by Ökopol)
  - Paints and varnishes (carried out by Ökopol)

[20] Some companies preferred to provide written information or even to have meetings with UBA. In the second project phase Ökopol held several face to face meeting or performed other exchange formats like phone conferences.

- Cosmetics (carried out by Ökopol)

Ökopol and RISE started to establish contacts in the beginning of March 2017. This chapter is rather an excerpt of the main findings from the interviews than a complete narrative of all details.

Overall 69 companies and other organisations were identified that could potentially contribute information. Interviews could not be arranged with all of them and some provided further input in written form. In some cases, no contact could be established but pieces of information could be directly retrieved from websites or publicly available documents on the internet.

2.2.4.1 Information retrieved from the interview process

The main observation from the interview process and the IT-based survey was that none of the contacted organisations and companies was aware of any intended use of C9-C14 PFCA and related substances (including the additional C15-C20). Some answers indicated that there might be some relevance for firefighting foams, but further discussions with stakeholders showed that this must be seen in the context of the continued use of PFOA that might contain the C9-C14 PFCA as an impurity, rather than a use of its own. The even chained representatives of the substances are produced via the so called “telomerisation process” that leads to a co-production of longer chained PFCA compounds, as there are C10, C12, C14 (and higher) due to statistical distribution of the C2 elongation reaction of the telomerisation process when e.g. PFOA was manufactured. The substances that are of relevance in this regard were the PFDA and the PFDoDA as the reactions maximum was on the PFOA and the PFHxA. As result of the substitution of PFOA, PFDA and PFDoDA were also removed from this reaction.

End users of firefighting foams claim that due to security reasons a full substitution of PFAS especially for large fuel tank fires is not possible. On the other hand, producers of alternatives claimed to have products available that pass all required tests (including requirements set by the German military). There is an indication that in some EU member states (MS) fluorinated foams are already being phased out for some of the fires that are seen as safety sensitive (e.g. airports in Sweden).

There was one historical application known where PFNA was used directly in the manufacture of the fluoropolymer PVDF. Similar to the manufacture of PTFE that was often manufactured with PFOA as a processing aid, two production pathways are possible:

- Suspension production (without PFNA)
- Emulsion production – (use of emulsifier PFNA)

One fluoropolymer manufacturer contacted, who was suspected to have performed this production method in the past, confirmed that this route is currently not applied anymore to their knowledge. For their own production they confirmed they do not and did not apply this production route in the past. Furthermore, this manufacturer, a member of the FlouroCouncil, was not aware of any other companies doing so within the organisation, which covers most US, Japanese and EU manufactures. A further fluoropolymer manufacturer, which is not a member of the group, was contacted directly and also confirmed they do not apply these method or ever did. It could not completely precluded by the contacted companies that manufacturers around the world might still use PFNA in the manufacture of PVDF, but with the stewardship program from the US EPA[21] this compound would also be in the scope of substitution activities. So none of the companies involved might still be using the compound.

According to industry information there is only one company that is performing the telomerisation process in the EU. Other manufacturers outside the EU (Russia) had been contacted but no response was received. This company nevertheless has published some information on the internet on substances they produce/are able to produce on request[22].

One manufacturer that performs this telomerisation process confirmed that in the mixed process in the past, different chain length PFCA have been produced. Main products have been historically PFOA and PFHxA which have been used to produce higher molecular polymeric structures. As a consequence of the PFOA restriction issued at the moment, the process was changed and optimised for the manufacture of C6 fluorinated compounds. Remaining reaction products of longer chain lengths have been separated with an efficiency that the proposed limits for the absence of PFOA in the C6 products are met[23]. In consequence, the chain lengths higher than C8 have already been efficiently eliminated as well. Estimates on PFDA molecules in the intermediate products of the process range in in concentrations way below the restriction limit for PFOA. This can also be stated for final polymers that meet the requirements of the restriction for PFOA, already. It should also be mentioned that the lower molecular C6 compounds themselves are products that are used by the company itself as intermediates or sold to customers that also use the substances for further polymerisation steps. In the latter case, they would be seen as transported isolated intermediates. This in conclusion leads to a situation where the on-site isolated intermediate stages would potentially be exempted from a new restriction according to Article 68 (1) of REACH, according to the manufacturer's position.

Another globally active fluoropolymer producer stated that in his own production no C9-C14 PFCA are used in the EU. However, the manufacturer could not preclude that some of these substances or related substances are used in own processes in non-EU production. It could not be excluded that the substances are used along the supply chain by market actors which are not directly under the influence of the manufacturer. Minimal use of C9-C14 is known in laboratory applications and research and development purposes in the range of a few grams to kilograms. One main product of this market actor are fabrics. All fabrics produced follow the quality standards of bluesign®, which does not allow the use of C9-C14 PFCA. Occasional additional product testing did not identify the substances up to the detection limit, which is usually (depending on the specific substance) < 1µg per m^2 of fabric.

These findings are supported by several other interviews with apparel companies. The Norwegian ban of PFOA in consumer products from June 2014 was referred to as one factor to substitute PFOA for durable water repellence (DWR) with a C6 based chemistry. The distribution of chain lengths in commercial PFAS products still indicates that longer chain lengths than C6 might be present. Laboratory tests performed by some companies after the substitution of PFOA showed traces of that compound were still present after it had no longer

[21] See US EPA https://www.epa.gov/assessing-and-managing-chemicals-under-tsca/risk-management-and-polyfluoroalkyl-substances-pfass

[22] See https://halopolymer.com/service (last retrived June 2019)

[23] Commission Regulation (EU) 2017/1000 of 13 June 2017 amending Annex XVII to Regulation (EC) No 1907/2006 of the European Parliament and of the Council concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) as regards perfluorooctanoic acid (PFOA), its salts and PFOA-related substances (*OJ L 150, 14.6.2017, p. 14–18)* states in this regard:
"Shall not, from 4 July 2020, be used in the production of, or placed on the market in:
(a) another substance, as a constituent;
(b) a mixture;
(c) an article,
in a concentration equal to or above 25 ppb of PFOA including its salts or 1 000 ppb of one or a combination of PFOA-related substances." Full text see: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1506601365194&uri=CELEX:32017R1000

been intentionally used. Longer chain lengths have not been analysed in these tests. PFAS (C6) treatment is used for a range of products where a high durability of the water repellence is required, especially for articles that are used by professional athletes (skiing, sailing) and for work wear. For latter it is also often important to ensure oil repellence. In addition, manufacturers claimed that this effect could not be realised with fluorine-free alternatives. One company, which does not supply professional equipment, has phased out PFAS, completely. Others still have a share of 20 % PFAS treated articles in their collection and are in the process of phasing out with the intention to achieve their aim by 2020. However, there is no indication this is related to an intentional use of C9-C14 substances. The substitution of PFOA was connected to higher prices for fabrics. Suppliers specified small volumes and higher effort for production. The initial price increase has dropped since the introduction of the alternatives. However, prices were reported to be higher than for the PFOA treated fabrics.

Some information on cost of substitution was given. It can be caused by a system change, production organisation has to be changed and/or by the cost for the substance or the overall substance consumption. Overall, the costs for PFAS-free fabric are estimated to be < 1 US $ (more in the range of 20 – 80 US Cent) higher compared to C6. It is not possible to break this down to substitution chemicals and other effects related to the production system. **NOTE**: the transition to C6 from C8 should already be included into the cost of the PFOA restriction so that no additional costs originate for the substitution of the longer chains.

One producer also reported that he is planning to introduce PFAS free leather. The main problem reported was to set up a PFAS free production line due to the low tonnages of leather used in overall production.

Full substitution of PFAS is sometimes limited due to some technical problems, either with water repellence performance or with other issues (as mentioned oil repellence but also the durableness of the treatment). One producer e.g. reported that the use of PFAS additionally mediated a stick effect of surfaces that supported the production of the final product and that is lacking alternatives. Therefore, the supplier refused to change the process to PFAS free production. No data on the residual content of C9-C14 PFCA were provided. But since they occur basically as an impurity from production of PFHxA in lower concentrations than PFOA, their presence should be well below the future threshold of that substance.

A producer of workers protection apparel reported a continued use of PFAS containing finishing. The main reason is the lower performance of fluorine free alternatives compared to fluorine-based chemistry with regard to dirt and water repellence. So, C6 chemistry is still in use since substitution of C8 chemistry was initiated. Nevertheless, like for all the other apparel applications, C9-C14 PFCA chemistry has never been actively used. Residues have always been in the materials due to impurities of formerly used chemistry. Since PFOA is about to be replaced no extra costs originate.

The other sector that is using fluorinated substances for treating surfaces is the paper industry. It is known that fluorinated compounds are used in food contact materials to mediate non-stick or dirt fat/moisture repellent properties. There is no or low indication that C9-C14 PFCA are released from these papers. Data provided by consumer NGO[24] show that the level of compounds with that chain lengths was always below 2 ng/dm^2 [(25)], respectively < 60 ng/g paper for 10:2 FTOH. An e-mail exchange with a large fast food company confirmed the results and it was stated that C9-C14 do not have any relevance for the paper they use. Currently, that

[24] Danish Consumer Council THINK Chemicals (pers. Comm.)

[25] PFNA, PFDA, PFDoDA, PFUnDA, PFTriDA

company is aiming for a complete phase out of fluorine from this paper (work ongoing). Details on a potential alternative were not provided.

The furniture sector was represented by two companies. Both companies produced products from semi-finished articles and do not treat the ingoing materials themselves (mainly home textiles and carpets). Both claimed that no intentional use of any PFAS is performed and there are no indications that the substances in scope of the restriction proposal can be found in the products. Nevertheless, they were not completely certain if there are fluorinated compounds introduced to their products by any of their suppliers.

For the paint sector CEPE as the association on EU level was contacted. The association had no indication that substances in the scope of the planned restriction are in use in the sector. The DIBt[26] in Berlin was also contacted in this regard. Although paints are not specifically in the scope of the institutes work, the assumption was that these substances would not be used in this kind of products. Recipes of closely related products like floor coverings do not indicate such use, so in their opinion they are unlikely to be used in paints.

A contact with the semiconductor industry indicated that the issue of restriction of C9-C14 PFCA is not an issue for that sector.

Some uncertainty does originate from research from cosmetics. On the one hand, there is no positive indication that C9-C14 PFCA are used in cosmetics. On the other hand, some potential precursors like e.g. “C6-14 PERFLUOROALKYLETHYL ACRYLATE/HEMA COPOLYMER” can be found in databases like CosIng[27]. Interviews with specific companies did not indicate any use of such substances, which is a basic problem of the database. It is not clear if and to what extend the substances in the database have been used in the past. Still, some publically available sources indicate that cosmetics can be a source of fluorinated substances.[28]

2.2.5 Conclusion

Neither the literature study, nor the survey, nor the interviews indicated that C9-C14 PFCA and related substances are used intentionally in any sector in the EU. In addition, most applications that can contain these PFCA as unintended impurities seem to be of very low relevance, as the restriction of PFOA is also a strong driver to remove this substance C6 compounds. As a side effect, it also removes the longer chain compounds of relevance. In other areas, where a shift towards shorter chain PFCA was implemented or fluorine was completely substituted, the process have been initiated to remove PFOA also. This means that costs for the purification of raw materials for products and/or substitution should not be allocated to a restriction of C9-C14 PFCA. There was no case described that mentioned substances of the current restriction proposal as a driver of such an activity. This is also true for the only direct application of one substance the PFNA. All contacted market actors described this as a historical use and substitution has rather been performed in the frame of the US EPA stewardship program. But similar to the situation for PFOA, large shares of the world production of PVDF are already free of PFNA and therefore a restriction could contribute to tackle potential imports that have not undergone substitution. It can be expected that market effects on the users of the PVDF are rather limited.

Other direct uses could not be identified. From a chemical and an economical perspective, this seems reasonable. When market actors want a very effective substance the use of PFOA leads to

[26] Deutsches Institut für Bautechnik: Section II 4 Health protection, Indoor hygiene, Building chemistry

[27] https://ec.europa.eu/growth/sectors/cosmetics/cosing_de

[28] Green science policy http://www.greensciencepolicy.org/wp-content/uploads/2014/10/Fluorinated-Chemicals-in-Cosmetics.xlsx

the best results in regard to the amount of substance to be used. Use of longer chain lengths would lead to following consequences:

- A decrease of the intended effect ⇒ As a result to overcome this effect, more of the chemical would be used to compensate this (the same would be true for shorter chains).
- Chemical production process needs more elongation cycles[29] and purification of unintended C8 products ⇒ This would increase the consumption of building blocks and energy, therefore a substitution by C6 or C4 would be much more process efficient.

In conclusion, one can say there is no incentive for users to apply C9-C14 PFCA (and also compound with even longer chain lengths to C20) since the use of PFOA led to the optimal technical result. To use the substances as substitutes would not be economical as performance of C6 or C4 would be similar with less production efforts.

There are strong indications that in many fields the restriction of PFOA also leads to a significant reduction of other compounds, since these were not initially produced for use but rather originate for the chain length distribution of the telomerisation process. So, it can be expected that emissions of C10, C12 and C14 from products that contain fluorinated substances based on telomerisation products have decreased in the last years.

Overall, it has to be concluded that no arguments could be found that would not justify the introduction of a restriction – neither on the technical level nor based on socio-economic effects.

[29] Telomerisation undergoes chain elongations of C_2

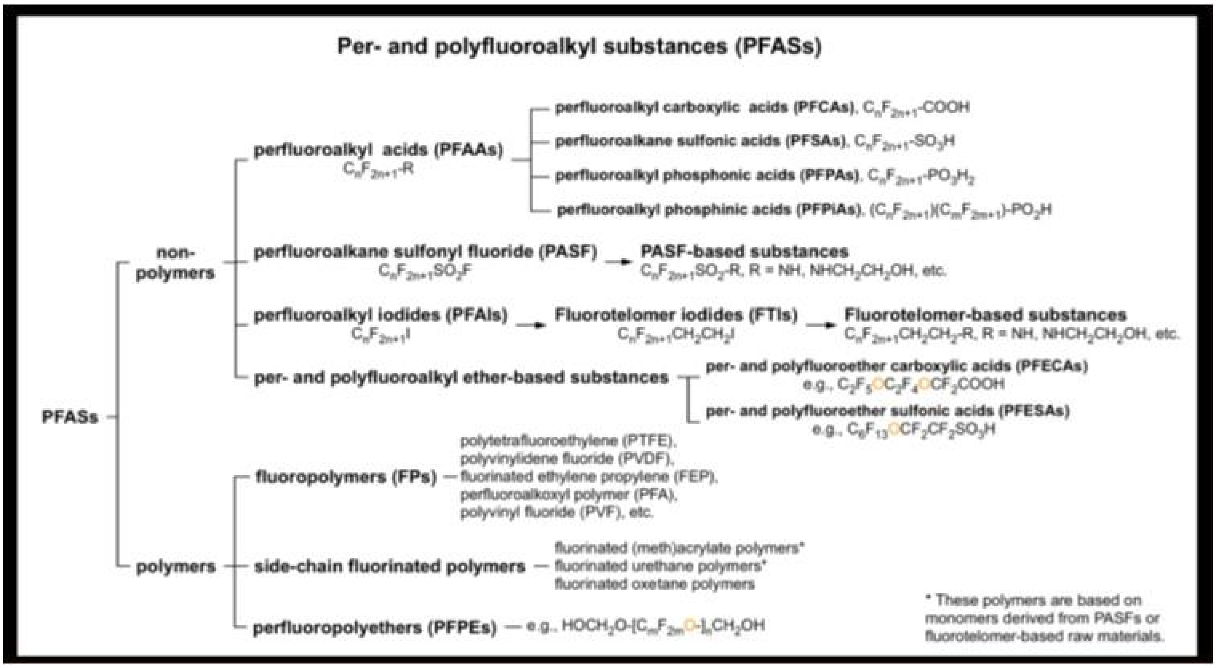
3 Phase 2: Information collection on short-chain PFAS

The second phase of the project covered representatives of short-chain poly- and perfluoro alkyl substances (PFAS). In particular, the UBA was interested in collecting information on the manufacture and use of short-chain PFAS. The aim was to identify areas of use that pose an unacceptable risk to the environment and/or human health, which needs to be addressed by an EU-wide regulatory measure under REACH (a restriction). Furthermore, the data collection covers the availability of alternatives to the use of fluorinated compounds and the socio-economic impacts of a potential restriction scenario for the various areas of application.

3.1 Literature study on short-chain PFAS “Publicly available sources and overviews on production and application for PFAS ”

The group of Per- and polyfluorinated substances (PFAS) includes a number of substances that contain one or more perfluoroalkyl moieties, –CnF2n+1 (linear or branched) or CnF2n (cyclic). Examples for PFAS with a widespread use are perfluoroalkyl carboxylic acids (PFCA) and perfluoroalkane sulfonic acids (PFSAs), and precursors of PFCA and PFSAs. Discussions regarding a consistent terminology for PFAS are ongoing. A suggestion provided by the Organisation for Economic Co-operation and Development (OECD) summarises PFAS as illustrated in the following figure. This terminology will be used throughout the remainder of this chapter; where the publications cited here diverge from the terminology, this is adapted without further notification.

Figure 1: Per- and polyfluorinated substances (PFAS) with subgroups according to the terminology suggested by OECD (OECD 2013)



Source: SYNTHESIS PAPER ON PER- AND POLYFLUORINATED CHEMICALS (PFCS) (OECD 2013, https://www.oecd.org/env/ehs/risk-management/PFC_FINAL-Web.pdf)

The literature and information search focussed on short-chain PFAS with a perfluorinated chain of up to six carbon atoms (five in case of PFSA) and substances for which uses are documented and which are known or assumed precursors of perfluoroalkyl acids (PFAA). As some of the studies included also information on LC PFAS which could be relevant for comparison, those substances are also mentioned where it was appropriate in the context. Cases where the definition of short-chain has been used differently, for example reports from 2015 that include PFHxS as a short-chain homologue, are adapted to fit the current definition. The search started in October 2017, databases and sources were revisited and updated until February 2019. Substances that have been listed for applications or have been identified through analytical studies are summarised in the following Table 3.

Table 3: List of PFAS substances, precursors and mixtures mentioned in the literature study

Substance name	Acronym	CAS-Number	EC-Number
2,2,3,3,4,4,4-Heptafluorobutanoic acid (C_4-PFCA)	PFBA	375-22-4	206-786-3
2,2,3,3,4,4,5,5,5-nonafluoropentanoic acid (C_5-PFCA)	PFPeA	335-76-2	206-400-3
2,2,3,3,4,4,5,5,6,6,6-undecafluorohexanoic acid (C_6-PFCA)	PFHxA	307-24-4	206-196-6
2,2,3,3,4,4,5,5,6,6,7,7-dodecafluoroheptanoic acid (C_7-PFCA – not short-chain))	PFHpA	1546-95-8	216-283-0
1,1,2,2,3,3,4,4,4-nonafluorobutane-1-sulfonic acid (C4-PFSA)	PFBS	375-73-5	206-793-1
1,1,2,2,3,3,4,4,5,5,5-undecafluoropentane-1-sulfonic acid (C5-PFSA)	PFPeS	2706-91-4	220-301-2
3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctane-1-sulfonic acid (6:2 fluorotelomer sulfonate)	6:2 FTS	27619-97-2	248-580-6
3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctan-1-ol	6:2 FTOH	647-42-7	211-477-1
3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl dihydrogen phosphate	6:2 monoPAP	57678-01-0	611-565-3
bis(3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl) hydrogen phosphate	6:2 diPAP	57677-95-9	n/a
1,1,2,2,3,3,4,4,4-nonafluorobutane-1-sulfonyl fluoride	PBSF	375-72-4	206-792-6
1,1,1,2,2,4,5,5,5-nonafluoro-4-(trifluoromethyl)-3-pentanone	3M Novec	756-13-8	436-710-6
1,1,2,2,3,3,4,4,5,5,6,6,6-tridecafluorohexyl phosphonic acid	PFHxPA	40143-76-8	206-587-1
phosphonic acid, perfluoro-C6-12-alkyl derivs.		68412-68-0	270-204-4

The literature and information search and evaluation for short-chain PFAS was designed taking in lessons learned from the previous work on LC PFAS (C9-C14) in Phase 1 of the project. A general overview of studies published in peer reviewed articles was performed to identify current research topics and to establish a link to potential sources. This was focussed on applications in products and measuring results related to point sources and excluded work on exposure where contributors were unknown. In parallel information available in reports and grey literature for application areas was evaluated. Among the reasons for this, is that short-chain fluorinated alternatives have been launched as substitutes when PFOA and PFOS were restricted, and it is assumed that the usage increased as a consequence. The initial development is described in "Fluorochemicals go Short" (Ritter, 2011), with the aim to achieve similar functional properties with reduced environmental impacts. Short-chain PFAS were initially identified as equally persistent but less bioaccumulative and with a potentially better toxicity profile. Societal benefits of fluoroproducts were emphasized by Ritter (2011), and the risk assessment was at the time not conclusive with associated precursors and derivatives to be scrutinized. Subsequently the mobility of short-chain homologues and the lack of options for remediation, once the substances are released to the environment, have been identified (Brendel et al., 2018).

Because of this general trend to replace long-chain homologues with short-chain-homologues, information on both short-chain and non-fluorinated alternatives for specific applications could to a certain extent be found in the document "*Guidance on best available techniques and best environmental practices for the use of perfluoro octane sulfonic acid (PFOS) and related chemicals listed under the Stockholm Convention*" (BAT/BEP Group of Experts, 2017). This contains an updated and consolidated summary of reports commissioned and published by national authorities.

Reports issued by technical authorities provide in many cases detailed information on application areas and products that were used as complementary to peer-reviewed publications. Information from reports is not peer-reviewed, and especially information on products, producers and applications is subject to change and has to be consolidated and potentially updated which was started already during the literature search.

3.1.1 Literature search: original analytical data peer-reviewed scientific publications and reports

The search strategy was designed to focus on identifying relevant applications for PFAA and precursors in products. A large share of the peer-reviewed scientific literature is however based on analytical studies that provide empirical data on the prevalence of PFAS in the environment, thus focussing on end-stage products such as PFCA. Publications on monitoring and sample analysis are often targeting end-stage metabolites occurring in the environment and do not always attempt to link the detected concentrations to a particular product or application as a source. Papers that focus exclusively on monitoring and analytical results are not prioritised here.

Titles and abstracts of publications as identified via Scopus/Science Direct, Citeseer X and Bielefeld Academic Search Engine (BASE) for open source publications and complementary Google Scholar were analysed to select a subset of publications that included (analytical) studies of contents in products and in specific point sources, such as industrial wastewater treatment. Further publications were identified from the bibliography in this subset. The following sections summarise results of the information search in peer-reviewed publications from this subset.

Publications on PFAS usually are not limited to a specific compound, but mention several compounds that were either measured together as part of a study, or where one can be used to substitute another, or where one compound is a metabolite of another; as an example, biotransformation of the substance 6:2 FTS to the end-stage metabolites PFHxA and PFPeA is described by Wang et al. (2011).

This also means the range covered in publications can be broad and include several homologues that fall into different categories regarding the chain-length, including both short-chain and long-chain homologues.

All PFAS have in common that the number of publications increased over the last decade. For the example of PFHxA, 198 documents published between 2005 and 2018 (one) have been found in October 2017 in the database Scopus (ScienceDirect); countries with most publications are China (59), USA (51) and Japan (28). Subjects are mostly related to analytical methods, monitoring in humans and the environment and the toxicological aspects. PFHxA are measured as part of surveys targeting a wider range of PFAS. The total number of hits in May 2019 has increased to 239, with China (78), USA (63) and Japan (31) contributing most publications.

Wang et al. point out that while a large number of publications is available for PFCA and PFSA, other substances are not covered equally wide (Wang et al., 2017). These include phosphorus containing fluorinated chemicals such as perfluorinated phosphonic acids (PFPA) and perfluorinated phosphinic acids (PFPiAs).

Precursors for which public information is available include fluorotelomer alcohols, (F(CF2) x C2H4OH, x = even number, FTOH) a substance group used in the production of fluorotelomer-based products. For the literature and information search, FTOH are included as precursors, with the main focus on 6:2 FTOH.

The biodegradation pathways of FTOH are subject of studies and it is pointed out that understanding is needed to identify appropriate metabolites (transformation products) for environmental monitoring. A widely cited review article from 2006 by Prevedouros et al. (2006) pointed to the hypothesis that atmospheric transport of volatile FTOH and degradation is a main source of (long-chain) PFCA in remote regions. Subsequently, further research on different degradation pathways FTOH to PFCA including aerobic biodegradation in soil and sludge (Liu et al., 2010b, 2010a; Zhao et al., 2013b) and anaerobic degradation in sediment (Zhao et al., 2013a) is reported.

Other biodegradation paths for 8:2-FTOH and 10:2 FTOH, but not for 6:2 FTOH, have been proposed for different biota (including rainbow trout, rats) as summarized by Butt et al. (2014).

Another relevant class of precursors for which degradation to PFCA as stable end-stage metabolites has been proposed are polyfluoroalkyl phosphate esters (PAPs) – also found as polyfluoroalkyl phosphoric acid esters (Lee et al., 2010; Liu and Liu, 2016). They are an important class of anionic fluorinated surfactants and have received considerable attention as contaminants of emerging concern. PAPs have been widely detected in the environment (in sludge, wastewater, and indoor dust) at levels similar to PFSA and PFCA.

The acronym PAP stands for a group of substances with one to three perfluorinated side chains, the current OECD terminology suggests the clarification "n:2 fluorotelomer alcohol phosphate esters" (PAPs) and categorises the substances as fluorotelomer-related compounds. Additionally the terminology includes perfluoroalkane sulfonyl amido ethanols phosphate esters (SAmPAPs), which are included in the category of perfluoroalkane sulfonyl compounds.; PAPs have been produced since the 1970s and used in paper, packaging material including food packaging, cosmetics and cleaning agents. Examples for compounds are included in Table 343– it is not known whether the examples, which were listed by Trier et al. (2011), are the ones with highest tonnages.

In the following sections, information from peer-reviewed articles and reports is compiled for known product groups and applications.

3.1.1.1 Products and applications: food packaging and food contact materials

Regular paper does not possess sufficient barrier properties and is not heat sealable to provide closed containers. Paper considered for food packaging is almost always treated, coated, or impregnated with additives. Food package samples manufactured and purchased in Greece (with the exception of microwave bags for pop-corn and rice, for which no manufacturing location is provided) were analysed by Zafeiraki (Zafeiraki et al., 2014). The samples included beverage (n=8) and ice cream (n=1) cups, fast food wrappers (n=6) and fast food paper boxes (n=8), paper for baking (n=2), microwave bags (n=3) and aluminium foil bags and wrappers (n=14). The values for n represent the respective sample sizes. Products were collected in Athens from October to December 2012. Besides short-chain PFAS, PFOS and PFOA were also analysed, but not detected in any samples.

PFHxA was detected in the ice cream cup with a concentration of 25.56 ng/g, where it was the only PFAS detected; all other PFAS including PFBA (LOD (limit of detection) =0.51 ng/g), PFPeA (LOD=0.39 ng/g) and PFBS (LOD=0.57 ng/g) were under the respective limit of detection; only a single ice cream cup was analysed.

PFHxA was also analysed in fast food wrappers and found in a maximum concentration of 19.17 ng/g; the minimum concentration was below LOD (LOD=0.94 ng/g). Note that only the sample size, minimum and maximum concentration is provided as a result in the study, no information is available regarding the detection frequency. For microwave bags the maximum concentration is given as 341.21 ng/g; minimum concentration is below LOD.

PFBA was detected in fast food wrappers with a maximum concentration of 3.19 ng/g, the minimum concentration was below LOD=0.51 ng/g; in microwave bags the maximum concentration was 275.84 ng/g, the minimum concentration was below LOD. PFPeA and PFBS were also analysed, but concentrations were below LOD (0.39 ng/g for PFPeA; 0.57 ng/g for PFBS) for all samples for both substances.

Fast food wrappers were the only product type where both short- and long-chain PFCA were detected together. The maximum concentration of PFHpA was 10.02 ng/g, lowest below LOD (=0.40 ng/g). For PFNA maximum concentration was 4.97 ng/g; lowest below LOD (=0.42 ng/g). For PFDA maximum concentration was 28.25 ng/g; lowest below LOD (=0.69 ng/g). For PFDoDA maximum concentration was 19.12 ng/g, lowest below LOD (=0.20 ng/g). Long-chain PFCA are listed here only for comparison and not target of this search.

There were also types of packages for which no PFAS were detected: aluminium packages, beverage cups, and paper for baking. No short-chain PFAS were detected in fast food boxes; long-chain PFCA PFTrDA, PFTeDA and PFHxDA were detected, but were below the level of quantification (LOQ).

Microwave bags were additionally analysed before and after cooking. The concentration of PFBA decreased and was 155.55 ng/g after compared to 275.84 ng/g before cooking. For PFHxA the concentration increased and was 681.35 ng/g after compared to 341.21 ng/g before cooking. For PFPeA, after cooking a concentration of 60.75 ng/g was measured, whereas the value before cooking was below LOD=0.39 ng/g. The authors suggest that an increase could be explained by the release of compounds from the matrix due to the temperature raise. Moreover, they attributed the lowering of PFBA concentrations after microwaving to its higher volatility (Zafeiraki et al., 2014).

Popcorn bags from different countries in Europe (Spain, France, Netherlands, United Kingdom, Germany, Hungary, Italy, Austria, Czech Republic, Ireland, Sweden), the Americas (USA, Mexico and Brazil) and Asia (India, China) were analysed in a study that included PFCA and precursors.

The products were purchased in 2015 to 2016, and all bags were manufactured in the corresponding country. In European and American countries mostly short-chain PFCA (C4–C8[30]) were detected. Potential precursors were also quantified; in European and American countries mostly 6:2 diPAP and its degradation intermediates were found (Zabaleta et al., 2017).

Another study from Spain was primarily focused on analytical methods, but reported also results for concentrations of PFBA, PFPeA, PFHxA and PFHpA (not further considered here) for popcorn microwave bags. The highest concentration was found for PFHxA (405 ng/g before and 497 ng/g after cooking, sample Salty A), followed by PFBA (236 ng/g before/280 ng/g after cooking, sample Butter A) and PFPeA (37 ng/g before and 43 ng/g after cooking, sample Butter A). The minimum concentration for PFHxA was 2.24 ng/g before and 3.4 ng/g after cooking, for sample Sweet A). PFHxA was found in all six samples. PFPeA was detected in three out of the six samples, the minimum concentration of those three was 26.6 ng/g before and 30.3 ng/g after cooking (sample Salty B). PFBA was detected in four out of the six samples, the minimum concentration is reported as 158 ng/g for both before and after cooking (sample Salty B). The authors also report that they did not detect PFAS in the popcorn itself. Since the focus of the study was on analytical methods and the results were mostly provided to illustrate the procedure, these observations are not elaborated in detail (Moreta and Tena, 2014). The samples were purchased in mid-2013 and the authors point out that PFOA, PFOS, PFDA and PFDoDA were not detected. A study on popcorn bags purchased in late 2011 performed by the same researchers had shown concentrations also for long-chain homologues (Moreta and Tena, 2013)

Possible precursors of short-chain PFAS were investigated in a study by Trier (Trier et al., 2011) who detected perfluorinated compounds in paper bags for microwave popcorn sold in Denmark (Popz Microwave Popcorn (DK) by Soller LLC, Micropop (DK) by Landlord, Micro Popcorn (DK) by Blomberg & Co. A/S, Master's Choice Popcorn (CD) by Master's Choice (CD) and in a cardboard Burger box (DK), for which the producer is McDonalds). The acronym CD is not explained in the original publication, based on current information a company with that brand exists in Canada. In nine products no concentrations above the LOD (15-22 µg/L) were found: Organic Micro popcorn (DK) by PopCo A/S, The President's Choice Organic Popcorn (CD) by Loblaws Inc (CD), Chocolate Cake Mix (DK) by Milestone A/S, Rye Bread Mix (DK) by Milestone A/S, Panang curry chicken with jasmine rice (DK) by CPF Food Products Co (Thailand), Lasagne Bolognese (DK) by Carlilli (DE), Coffee Cup (DK) by 7-11, Fast Noodles (DK), unknown producer, and Coffee Cup (DK) produced for and purchased at the University Cantina in Copenhagen. The detected compounds are listed as diPAPS (x:2/y:2 FTOH di- substituted phosphate surfactant or disubstituted phosphate surfactants; trade names Zonyl NF, Zonyl UR2, Zonyl FSE) and S-diPAPS, (x:2/y:2 FTOH di- substituted thioether phosphate surfactant with trade name Lodyne P208E). The measured structures include compounds with side chains of fluorinated chain length of six or four, but the exact compounds are not disclosed. Examples for monoPAPs and diPAPS are included in Table 3 (p. 43). No quantitative analysis results are reported, the results are presented as screening results. Zonyl is a trademark of Chemours (earlier DuPont), Lodyne was a trademark of CIBA/BASF.

A study of consumer products including paper based FCM was carried out by (Kotthoff et al., 2015). The food contact materials included 33 individual samples, which were analysed for PFCA/PFSAs, and 7 pooled samples, which were analysed for FTOHs. Some paper-based materials were supplied from stored materials. In those cases, the production year was not known and ranges from a few years to decades before the study were performed. The maximum

[30] While the C8 per definition is not a short chain PFAS per definition. Nevertheless, it is included here because the scope of the investigations usually covered these as well.

results for PFBA were 9.9 µg/kg, for PFPeA 33.3 µg/kg, for PFHxA 182.8 µg/kg. For PFBS the result was below LOQ. The median results for PFBA were 0.7 µg/kg, for PFPeA 15.4 µg/kg, for PFHxA 1.4 µg/kg. For PFBS, the result was below LOQ. The percentages of samples with results above LOQ are 44% for PFBA, 73% for PFPeA and 27% for PFHxA. 6:2 FTOH was detected in a concentration of 4.4 µg/kg in a pooled sample. Further information on the study including LOQ and results for other consumer products are provided in the section on consumer products (chapter 3.1.1.2).

The focus of studies summarised so far was on food packaging and paper-based food contact materials (FCM), materials that come in contact with food include also kitchen utensils, such as frying pans with non-stick coating.

For frying pans labelled as "PFOA free" and bought in German stores in 2012 gaseous emissions of PFCA were trapped by a precleaned glass lid connected to glass vials in an overheating scenario during which the empty pans were heated for 30 minutes at 3000 W. Maximum temperatures were 300ºC for Pan A and Pan D, 250ºC for Pan B and 370º C for Pan C. The temperatures are different due to different construction and heat capacity of the products. Pan D was a ceramic coated pan (thus not containing PFAS) that was included to determine the method blank. The results are provided in ng/h to estimate emissions to the surrounding indoor environment. Emissions for Pan C, which also reached the highest temperature, were the highest altogether, and reached 4934 ng/h for PFBA, 2106 ng/h for PFPeA and 1317 ng/h for PFHxA. For comparison, long-chain PFCA were reported as 862 ng/h for PFHpA[31], 692 ng/h for PFOA, 841 ng/h for PFNA, 744 ng/h for PFDA, 499 ng/h for PFUnDA and 198 ng/h for PFDoDA. Emissions measured for the other pans were for PFBA 58.1 ng/h (Pan A), 217 ng/h (Pan B) and 1.42 ng/h (Pan D, blank with ceramic coating); for PFPeA 58 ng/h (Pan A), 245 ng/h (Pan B) and 0.79 ng/h (Pan D, blank with ceramic coating); for PFHxA 12.9 ng/h (Pan A), 31 ng/h (Pan B) and 0.27 ng/h (Pan D, blank with ceramic coating). Temperature was identified as the most significant parameter and thermolysis of PTFE as a probable formation process. Impurities from production were not considered a likely source for short-chain PFAS (Schlummer et al., 2015).

3.1.1.2 Products and applications: consumer products

A wider range of consumer products with 115 samples were investigated for PFCA, PFSAs and FTOHs including short-chain homologues by (Kotthoff et al., 2015). In total analyses were performed for 11 PFCA (PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUnDA, PFDoDA, PFTrDA, PFTeDA), 5 PFSA (PFBS, PFHxS, PFHpS, PFOS, PFDS), 4 fluorotelomer alcohols (4:2 FTOH, 6:2 FTOH, 8:2 FTOH, 10:2 FTOH) and perfluorooctane sulfonamide (PFOSA). Only short-chain homologues are addressed here. Products were purchased in 2010. For ski wax the study states that the samples were obtained from ski clubs, therefore the production time is not clear. An overview of the product groups, number of analyses and target compounds is shown in the following Table 4.

Table 4: Overview of consumer products analysed by Kotthoff et al. (Kotthoff et al., 2015)

Product groups	Sample size, total	Analysed for PFCA/PFSAs	Analysed for FTOH
Cleaning agents	9	6	3
Carpet samples	14	6	8

[31] This substance is per definition not a long chain PFAS, but was also analysed and the result was included in this report.

Product groups	Sample size, total	Analysed for PFCA/PFSAs	Analysed for FTOH
Impregnating sprays	16	3	13
Outdoor textiles	5	3	4
Gloves	3	3	1
Leather samples	13	13	0
Ski waxes	13	13	0
Wood glue	1	1	0
Awning cloth	1	1	0

The study included PFBA, PFPeA, PFHxA, PFBS and the precursors 4:2 FTOH and 6:2 FTOH as target compounds and maximum results are summarised in the following Table 5.

Table 5: Maximum results for consumer products analszed by Kotthoff et al. (Kotthoff et al., 2015)

Product groups	PFBA Max	PFPeA Max	PFHxA Max	PFBS Max	Unit
Cleaning agents	<LOQ	<LOQ	<LOQ	<LOQ	µg/kg
Carpet samples	14.7	4.4	0.8	26.8	$\mu g/m^2$
Impregnating sprays	2.5	<LOQ	14.1	<LOQ	µg/kg
Outdoor textiles	6.1	39.7	17.1	<LOQ	$\mu g/m^2$
Gloves	1.2	76.1	2.6	2.0	µg/kg
Leather samples	241.8	197.1	4.5	143	$\mu g/m^2$
Ski waxes	362.1	440.3	1737.1	3.1	µg/kg
Wood glue	<LOQ	<LOQ	<LOQ	<LOQ	µg/kg
Awning cloth	0.5	8.5	1.0	<LOQ	$\mu g/m^2$

For PFAA, LOQs of 0.1–0.5 µg/ kg or 0.02–0.5 $\mu g/m^2$ were derived from the extrapolation of the calibration lines according to the German standard DIN 32645. LOQs were routinely set to 0.5 µg/kg or 0.5 $\mu g/ m^2$ for all analytes in all matrices. The authors indicate that this approach stresses the focus of this study in dealing with highly contaminated samples relevant for exposure scenarios. No minimum concentrations are reported. Additionally to maximum concentrations, median concentrations and detection frequency are provided for the products with the exception of leather samples (see Table 6 -Table 7). No explanation is provided for this omission.

Leather and ski wax samples (for PFCA) show high maximum concentrations; ski waxes also show high median concentrations. Note that the units are different, and a direct comparison is not possible.

Table 6: Median results for consumer products analysed by Kotthoff et al. (Kotthoff et al., 2015)

Product groups	PFBA Median	PFPeA Median	PFHxA Median	PFBS Median	Unit
Cleaning agents	<LOQ	<LOQ	<LOQ	<LOQ	µg/kg
Carpet samples	<LOQ	1.4	<LOQ	<LOQ	µg/m²
Impregnating sprays	1.4	<LOQ	6.9	<LOQ	µg/kg
Outdoor textiles	0.5	2.3	1.5	<LOQ	µg/m²
Gloves	0.8	3.1	1.3	<LOQ	µg/kg
Ski waxes	14.3	18.6	17.9	<LOQ	µg/kg
Wood glue	<LOQ	<LOQ	<LOQ	<LOQ	µg/kg
Awning cloth	0.5	5.8	0.9	<LOQ	µg/m²

Table 7: Percentage of samples with detected PFAS for consumer products analysed by Kotthoff et al. (Kotthoff et al., 2015)

Product groups	PFBA	PFPeA	PFHxA	PFBS	Unit
Cleaning agents	0	0	0	0	%
Carpet samples	50	90	40	45	%
Impregnating sprays	56	22	67	0	%
Outdoor textiles	33	78	56	0	%
Gloves	100	0	100	0	%
Ski waxes	65	100	88	38	%
Wood glue	0	0	0	0	%
Awning cloth	0	0	0	100	%

The maximum results for FTOHs as precursors are summarised in the following Table 8. Leather samples, ski waxes, wood glue and awning cloth were not included in this analysis.

Table 8: Maximum results for short-chain FTOH in consumer products analysed by Kotthoff et al. (Kotthoff et al., 2015)

Product groups	4:2 FTOH	6:2 FTOH	Unit
Cleaning agents	<LOQ	38,700	µg/kg
Carpet samples	<LOQ	21.2	µg/m²
Impregnating sprays	329,000	440,000	µg/kg
Outdoor textiles	<LOQ	15.8	µg/m²
Gloves	<LOQ	9.0	µg/kg

4:2 FTOH was only detected in impregnating sprays, which showed high concentrations for all analysed FTOH. In cleaning agents 6:2 FTOH was detected in high concentration; other samples showed low concentrations.

Long-chain PFCA were also analysed, but are not discussed here in detail as they are out of scope for this study. They are however reported to allow for a comparison and indicate that short-chain PFAS are potentially not used intentionally but occur as a contamination of products based on long-chain homologues. High concentrations of long-chain homologues exceeding the concentrations for short-chain homologues were detected in ski wax with a maximum of 2033.1 µg/kg analysed for PFOA and in impregnating sprays with a maximum of 719,300 µg/kg for 8:2 FTOH. For the short-chain homologues, see the values in the tables above.

Liu et al. (Liu et al., 2015) determined the concentrations of several FTOHs, among them 6:2 FTOH, in 54 consumer products collected from the U.S. open market in the years 2011 and 2013. The results are summarised in the following Table 9.

Table 9: Results for 6:2 FTOH in consumer products analysed by Liu et al. (Liu et al., 2015)

Product	Max	Min	Samples with concentrations >LOQ, total	Unit
Carpet	1300	<LOQ	1 out of 5	ng/g
Commercial carpet care liquids	105000	<LOQ	2 out of 3	ng/g
Household carpet/ fabric-care liquids	<LOQ	<LOQ	0 out of 2	ng/g
Treated apparel	<LOQ	<LOQ	0 out of 11	ng/g
Treated home textiles and upholstery	21200	<LOQ	4 out of 5	ng/g
Treated non-woven medical garments	470	<LOQ	2 out of 5	ng/g
Treated floor waxes and stone/wood sealants	331000	1590	5 out of 5	ng/g
Treated food contact paper	12700	<LOQ	3 out of 9	ng/g
Membranes for apparel	1590	<LOQ	1 out of 4	ng/g
Thread-sealant tapes	754	<LOQ	1 out of 4	ng/g

Treated floor waxes and stone/wood sealants included the sample with the highest concentration and were also the product group for which each sample contained 6:2 FTOH. No 6:2 FTOH was detected in treated apparel and in household carpet/fabric-care liquids. However, both of those product groups did contain 8:2 FTOH. Values for LOQ are not provided by the authors.

In an earlier publication for consumer products purchased between 2007 and 2011, the authors point out that the presence of PFBA and PFPeA in products has increased during that time. This observation is only illustrated with a diagram (which shows a similar trend for PFOA), no quantitative data are shown (Liu et al., 2014).

Outdoor textiles on the Norwegian market were analysed for ionic perfluorinated substances by Hanssen and Herzke (Hanssen and Herzke, 2014). The analysis included short-chain PFSAs (PFBS) and precursors (6:2 FTS, 4:2 FTS) and PFHxA as a short-chain PFCA. Only for PFHxA concentrations above the LOD concentration were found in 4 out of 12 tested items. The highest concentration reported is 7.97 µg/ m^2; for eight items the concentration for PFHxA was below the LOD (0.6 µg/ m^2).

Outdoor jackets on the German market were analysed for a variety of PFAS including short-chain PFAS by Knepper et al. (Knepper et al., 2014); a total of 15 items in different price ranges and for different user groups including children and professionals (work wear). PFBS was detected in one of the products, a hardshell jacket from a low price range with a concentration of 0.51 µg/ m^2. Short-chain PFCA were detected in several items, PFBA was detected in three out of the 15 items with a maximum concentration of 1.52 µg/ m^2 (work wear); PFPeA was detected in six items with a maximum concentration of 4.23 µg/ m^2 (work wear) and PFHxA was detected in 13 items with a maximum concentration of 14.7 µg/ m^2 (work wear). 6:2 FTOH was detected in two items with a maximum concentration of 18.6 µg/ m^2 (rain jacket, high price range). While the work wear item did stand out regarding concentrations of PFCA, it is not possible to identify a relation between price and origin of items and the concentration of PFAS.

Among early publications on PFAS in consumer products is a pilot study from 2009 for Norway based on previous knowledge that FTOHs are used to treat paper to improve its moisture and oil barrier properties and as a waterproofing agent for textiles (Herzke et al., 2012). The pilot study investigating potentially PFAS-treated products was initiated by the Norwegian Agency for Environment and Climate and included a spot-check sampling, rather than an in-depth sampling campaign. Samples were purchased in summer 2009 and included most common brands on the market. The main objective of the study was to explore less investigated consumer products regarding their potential to contribute to PFAS exposure. Sample candidates were identified in different ways: (i) by having certain properties that are common for the presence of PFAS (e.g. water repellent, stain resistant, anti-grease, non-stick, surfactant), (ii) by their previous known high concentration of PFAS (Teflon tablecloth, aqueous film forming foams (AFFF), water proofing agents), (iii) by information from literature that production of these articles may involve fluorinated chemicals (epoxy resin board, semi-conductor fabrication, etc.). AFFF are also used by professional firefighting brigades; they are included here because of their use in fire extinguishers used for example in private homes or at workplaces by persons with limited training.

Six different product groups were sampled in Norway and supplementary in Sweden which is a common destination for Norwegian consumers to purchase consumer goods due to lower price levels in Sweden (border trade) and therefore considered for the Norwegian market (Herzke et al., 2012). The product group “waterproofing agents” included different brands of water- and dirt-proofing agents and a lubricant, all from different producers. The product group “paint” included wet room sealing paint. The sample group “impregnated products” included textiles used for office furniture and tablecloth, carpets, food contact paperboard and leather. The group “electronics” included several printed circuit boards (PCBs). The group “firefighting agents” included two powder foams and three AFFFs.

Results are described for product groups. One out of three paint samples contained PFBA with a concentration of 2.53 µg/kg; no other short-chain PFAS or FTOHs were found. Printed cardboards contained trace amounts of 6:2 FTS with concentrations of 0.12 and 0.57 µg/kg. One carpet sample contained 1.35 µg/L 6:2 FTS and 220 µg/kg 6:2 FTOH, a second sample contained 17 µg/kg 6:2 FTOH and no other short-chain PFAS.

For water proofing agents, five samples were analysed. In one of them PFBS was found with a concentration of 38.85 µg/L, for the other samples the substance was not detected. PFBA was detected in all five samples with concentrations between 75.9 and 142 µg/L. PFHxA was found in two samples with concentrations of 23 and 25.6 ng/L respectively. 6:2 FTOH was detected in three samples with concentrations of 535, 1750 and 13250 µg/L respectively.

In AFFF Number 3 a concentration of 776000 µg/L 6:2 FTS, 960 µg/L PFBA, 1625 µg/L PFPeA, 3810 µg/L PFHxA and 848µg/L 6:2 FTOH were detected; AFFF Number 2 contained 8400 µg/L 6:2 FTS, 253700 µg/L PFBS, 27647 µg/L PFBA and 125000 µg/L PFPeA; AFFF Number 1 contained 37700 µg/L 6:2 FTS, 404 µg/L PFBA, 966 µg/L PFPeA and 1610 µg/L 6:2 FTOH.

Coated textiles contained 19 and 5.4 µg/kg 6:2 FTOH and no other short-chain PFAS. Coated cardboard for food packaging contained PFBS with concentrations of 308 and 1.36 µg/kg and 6:2 FTOH with concentrations of 13.1 µg/kg and 231 µg/kg, no other short-chain PFAS were detected. No PFAS were detected in other coated cardboard material. In non-stick cookware samples PFBA were detected with concentrations between 4.68 and 805 µg/kg, and one out of five samples contained additionally 6:2 FTOH with a concentration of 5.9 µg/kg (Herzke et al., 2012).

Schlummer et al. (Schlummer et al., 2013) investigated different indoor (work) environments where PFCA treated products were present. For one group of samples carpets with a fluorine-based coating were expected to contribute to emissions: this group included a carpet shop and two conference/office rooms of different ages (2 and 10 years since furnishing). The second group of sites was equipped with textiles with suspected water and dirt repelling surface treatment: the interior of a nine-month-old car and shops selling sportswear and outdoor textiles and/or materials. A third group contained different sources: a shop selling football shirts, shoes and leather care products like impregnation sprays, a kitchen mainly used for preparation of small lunches in which paper-based and fluorine-containing packaging is used, and two workshops specialised in metal work and car lacquering. In the same study consumer products were investigated: children's rain trousers and children's gloves, five outdoor jackets with and without membranes and outdoor trousers. The sample collection duration was between 5 hours and 39 minutes for the car interior and approximately 24 hours for a workshop with most between 13- and 17-hours sampling duration. The sampled air volumes varied between approximately 6000 m^3 for the car interior and 26000 m^3 for the workshop. Temperature at the sampling sites was for most sites 20°C, for the workshop it was between 20°C and 30°C. Results for the indoor air samples showed that 4:2 FTOH was not detected in any sample. Concentrations for 6:2 FTOH were measured with highest values in the two outdoor shops with 46.80 ng/m^3 and 46.12 ng/m^3 followed by the carpet shop with 35.96 ng/m^3. All other samples had concentrations below 10 ng/m^3.

In the Nordic countries further studies were published as reports following the Nordic Risk Assessment Project (NORAP). One study investigated the occurrence of PFAS including short-chain variants in consumer products in Norway (Blom and Hanssen, 2015). 29 samples purchased in supermarkets in the vicinity of Oslo in 2014 were investigated, an overview on product groups is provided in the following Table 10.

Table 10: Consumer products analysed by Blom and Hanssen (Blom and Hanssen, 2015)

Product group	Number of items, comment
Table cloth	2; 1 labelled as "Teflon"
Baking paper	2
Sandwich paper	1
Cupcake form	1
Microwave popcorn bag	2; both salty
Car wax	2
Dishwasher liquid	2
Waterproof treatment for shoes	2
Waterproof treatment for textiles	2
Glider for ski	2
Ski wax	1
Bicycle lubricant	1, labelled as Teflon grease tube
Dental floss	2
Non-sticking baking ware silicon	2
Non-sticking baking ware cupcakes	2
Reusable baking liner	2

The target compounds included PFBA, PFHxA, PFBS, 6:2 FTOH and PAPs/diPAPs. Several substances were not found in any samples including the short-chain PFAS 4:2 FTS, 4:2 FTOH, 6:2 PAP, and 6:2 diPAP.

Results for PFBA, PFHxA and 6:2 FTOH are shown in the following Table 11. PFBS was for most samples detected with values below LOD=0.1 µg/L (0.1 µg/kg, 0.1 µg/ m^2 depending on the product group), low concentrations were detected in non-stick baking ware cupcake, maximum 0.029 µg/ m^2, and reusable baking liner, maximum 0.019 µg/ m^2. The results are reported according to the information provided by (Blom and Hanssen, 2015); the maximum concentrations for PFBS are below the value for LOD.

Table 11: Short-chain PFCA in consumer products analysed by Blom and Hanssen (Blom and Hanssen, 2015)

Product group	PFBA max	PFBA min	PFHxA max	PFHxA min	Unit
Table cloth	2.45	0.8	6.81	0.497	µg/m^2
Baking paper	<LOD	<LOD	<LOD	<LOD	µg/m^2
Sandwich paper	0.103	n/a, 1 sample	0.434	n/a, 1 sample	µg/m^2
Cupcake form	<LOD	n/a, 1 sample	<LOD	n/a, 1 sample	µg/m^2
Microwave popcorn bag	34.5	<LOD	38.9	<LOD	µg/m^2

Product group	PFBA max	PFBA min	PFHxA max	PFHxA min	Unit
Car wax	<LOD	<LOD	<LOD	<LOD	µg/L
Dishwasher liquid	1.12	<LOD	<LOD	<LOD	µg/L
Waterproof treatment for shoes	0.752	<LOD	<LOD	<LOD	µg/L
Waterproof treatment for textiles	0.811	<LOD	<LOD	<LOD	µg/L
Glider for ski	3.45	1.03	<LOD	<LOD	µg/kg
Ski wax	6.71	n/a, 1 sample	<LOD	n/a, 1 sample	µg/kg
Bicycle lubricant	0.377	n/a, 1 sample	<LOD	n/a, 1 sample	µg/kg
Dental floss	<LOD	<LOD	<LOD	<LOD	µg/kg
Non-sticking baking ware silicon	<LOD	<LOD	<LOD	<LOD	µg/m^2
Non-sticking baking ware cupcakes	<LOD	<LOD	<LOD	<LOD	µg/m^2
Reusable baking liner	<LOD	<LOD	<LOD	<LOD	µg/m^2

LOD for PFBA is listed as 0.05 µg/kg (or µg/l; µg/ m^2 respectively); LOD for PFHxA is listed as 0.1 µg/kg (or µg/l; µg/ m^2 respectively). Samples with low concentration of PFBA in the range of 1 µg/kg were sandwich paper, dishwasher liquid, waterproofing agents, and bicycle lubricant. Higher concentrations were detected in tablecloth with a concentration of 2.45 µg/m^2, one microwave popcorn paper with a concentration of 34.5 µg/ m^2, glider for ski with a maximum concentration of 3.45 µg/kg, and ski wax with concentration of 6.71 µg/kg. Where two samples for a product were investigated, only one showed elevated levels; as an example, for the second sample listed as popcorn paper concentrations are listed as below LOD. For PFHxA, the results were below LOD for a wide range of product groups. Low concentrations were reported for sandwich paper. Higher concentrations were found for tablecloth, maximum 6.81 µg/m^2, and popcorn paper, maximum 38.9 µg/kg.

Table 12: 6:2 FTOH in consumer products analysed by Blom and Hanssen (Blom and Hanssen, 2015)

Product group	6:2 FTOH max	6:2 FTOH min	Unit
Table cloth	129	1.66	µg/m^2
Baking paper	1.37	1.22	µg/m^2
Sandwich paper	1.70	n/a, 1 sample	µg/m^2
Cupcake form	<LOD	n/a, 1 sample	µg/m^2
Microwave popcorn bag	16.3	1.14	µg/m^2
Car wax	0.263	<LOD	µg/L
Dishwasher liquid	0.391	<LOD	µg/L
Waterproof treatment for shoes	2.41	<LOD	µg/L

Product group	6:2 FTOH max	6:2 FTOH min	Unit
Waterproof treatment for textiles	259	<LOD	µg/L
Glider for ski	0.741	0.170	µg/kg
Ski wax	0.623	n/a, 1 sample	µg/kg
Bicycle lubricant	0.114	n/a, 1 sample	µg/kg
Dental floss	0.567	0.210	µg/kg
Non-sticking baking ware silicon	19.1	5.85	µg/m^2
Non-sticking baking ware cupcakes	16	1.4	µg/m^2
Reusable baking liner	<76.4	6.53	µg/m^2

Samples with low concentration of 6:2 FTOH were gliders for ski, ski wax, lubricant for bicycles, car wax, and dishwasher liquid with concentrations of up to 5 µg/kg. Samples with higher concentration were table cloth, with a maximum of 129 µg/ m^2, micro wave popcorn bag, maximum 16.3 µg/ m^2, waterproofing for textiles, 259 µg/kg, and non-stick baking ware products with maximum concentration of 76,8 µg/kg in reusable baking liner (see Table 12).

The authors conclude that the overall concentration levels are decreased compared to initial NORAP results, and more short-chain PFAS are found compared to earlier studies.

A study for Sweden also investigated PFAS in consumer products (Borg and Ivarsson, 2017, Table 13), and used similar samples based on the findings by (Blom and Hanssen, 2015).

Table 13: Product groups analysed by Borg and Ivarsson (Borg and Ivarsson, 2017)

Product group	Number of items, comment
Cupcake form	1
Microwave popcorn bag	4; 1 salty, 2 butter, 1 organic
Car wax	2
Rinse aid	2
Waterproof treatment for shoes	2
Waterproof treatment for textiles	2
Waterproof treatment for textiles and leather	1
Shoe wax	1
Floor polish	1
Furniture polish	2

Analyses included the short-chain PFAS PFBA, PFHxA, PFBS, 4:2 FTOH and 6:2 FTOH. 4:2 FTOH was below LOD in all samples. LOD are not provided in the study, a column with the heading “detection limit” in the annex does not contain any values. This applies for all analytes. The original report states the same unit for all product groups (see Table 14 and Table 15).

Table 14: Analytical results for short-chain PFCA in the samples analysed by Borg and Ivarsson (Borg and Ivarsson, 2017)

Product group	PFBA max	PFBA min	PFHxA max	PFHxA min	Unit
Cupcake form	0.05	n/a, 1 sample	<LOD	n/a, 1 sample	µg/m²
Microwave popcorn bag	0.43	0.21	0.65	<LOD	µg/m²
Car wax	<LOD	<LOD	0.54	<LOD	µg/m²
Rinse aid	<LOD	<LOD	<LOD	<LOD	µg/m²
Waterproof treatment for shoes	0.33	<LOD	2.5	<LOD	µg/m²
Waterproof treatment for textiles	0.8	0.78	3.6	2.3	µg/m²
Waterproof treatment for textiles and leather	<LOD	n/a, 1 sample	<LOD	n/a, 1 sample	µg/m²
Shoe wax	<LOD	n/a, 1 sample	4.7	n/a, 1 sample	µg/m²
Floor polish	0.47	n/a, 1 sample	5.3	n/a, 1 sample	µg/m²
Furniture polish	<LOD	n/a, 1 sample	<LOD	n/a, 1 sample	µg/m²

Table 15: Analytical results for 6:2 FTOH in the samples analysed by Borg and Ivarsson (Borg and Ivarsson, 2017)

Product group	6:2 FTOH max	6:2 FTOH min	Unit
Cupcake form	<LOD	n/a, 1 sample	µg/m²
Microwave popcorn bag	26.6	<LOD	µg/m²
Car wax	<LOD	<LOD	µg/m²
Rinse aid	<LOD	<LOD	µg/m²
Waterproof treatment for shoes	120300	<LOD	µg/m²
Waterproof treatment for textiles	43070	<LOD	µg/m²
Waterproof treatment for textiles and leather	12340	n/a, 1 sample	µg/m²
shoe wax	<LOD	n/a, 1 sample	µg/m²
Floor polish	1834	n/a, 1 sample	µg/m²
Furniture polish	<LOD	n/a, 1 sample	µg/m²

Concentrations were reported for one of the four micro wave popcorn bags (26.6 µg/ m^2), for the three others the result was <LOD.

Moreover, the samples previously investigated in the study by Blom and Hanssen (2015) were analysed together with textile samples (jackets and children jackets collected in 2015) to determine the total organic fluorine (TOF) content. The aggregated concentrations of PFAS explained in one case 10 % of the TOF value (floor polish), for all other samples it was under 1 %. Similar results were revealed for the samples originally analysed by Blom and Hanssen (2015). No explanation is provided regarding which other compounds and substances contribute to TOF.

In summary, the above mentioned reports from the Nordic countries Norway, Sweden and Denmark focusing on occurrence of PFAS in consumer products found short-chain PFAS in various products, mostly with low concentrations. Results also indicate that PFAS are not used in all cases to provide a specific function, there are single items in a product group for which PFAS are detected, while for others with similar function the result is under the LOD. The investigated products are similar to those listed in peer-reviewed publications.

3.1.1.3 Products and applications: personal care products

Personal care products, such as sunscreen and cosmetics for oil and water repellency, were investigated in a Japanese study focusing on polyfluoroalkyl phosphate esters (PAPs). The products listed PAPs as ingredients, the presence of PAPs in the samples was not investigated. PFHxA was detected in 12 out of 15 samples with concentrations from 4.7 ng/g in a base coat (nail polish) to 2100 ng/g in a foundation. 6 out of 8 Sun-screen products contained PFHxA with concentrations between 180 and 6500 ng/g. Whether this is an impurity of the PAPs or result from transformation processes is unknown (Fujii et al., 2013).

3.1.1.4 Products and applications: AFFF used by professional firefighting brigades

For AFFF potential applications in consumer products have been investigated as described above, but a majority of studies aimed to investigate use of PFAS by professional firefighting brigades. With this application for large scale fires, risks for contamination of water and soil have to be considered additionally to exposure during use. An analysis of selected firefighting foams on the Swedish market used by professionals in 2014, commissioned by the Swedish Chemicals Agency, included short-chain PFCA, PFBS and 6:2 FTS in a target analysis. PFBS was not detected in any sample.

Results for seven samples taken from distributors or intact containers are summarised in the following Table 16.

Table 16: Results for short-chain PFCA and 6:2 FTS (all µg/kg) analysed in AFFF (KEMI 2015b)

Product	PFBA	PFPeA	PFHxA	6:2 FTS
OneSeven B-AR	1485	1122	512	2407
ARC Miljö 3	546	108	1074	4373
Towalex plus	<1	78	1481	3449
Towalex 3x3	1008	551	9770	8130
Towalex 3% super	<1	<1	84	284
Towalex 3% master	1142	620	10352	4109

Product	PFBA	PFPeA	PFHxA	6:2 FTS
Sthamex AFFF-P 3%	83	17	83	9498

Tentatively identified compounds as main ingredient were 6:2 fluorotelomer sulphonamide amine (CAS 80475-32-7) in the product ARC Miljö 3, 6:2 FTAB (fluorotelomer sulphonamide alkylbetaine, CAS 34455-29-3) and 6:2 FTSAS (fluorotelomer mercaptoalkylamido sulfonate, no CAS provided) in different Towalex products. 6:2 FTAB was also tentatively identified as main ingredient in the product Sthamex AFFF P-3. Towalex is a brand name of Tyco, Sthamex is a brand name of Dr. Sthamer, ARC Miljö is a brand name of NFRS and OneSeven is a brand name of Dafo Brand AB (KEMI, 2015b).

6:2 FTSAS and 6:2 FTAB, marketed as Forafac 1157 (brand name by DuPont/Chemours; Capstone 1157), were both also identified as novel surfactants in AFFFs by d'Agostino and Mabury (D'Agostino and Mabury, 2014). The authors refer additionally to the use of fluorotelomer betaines (FTBs) as reported in studies for AFFF use for US military institutions (Place and Field, 2012). The sample collection dates for that study were between 2004 and 2007, indicating that the use of these substances was well-established. No quantitative information is reported. The authors observed that several products contained a fluorinated amphoteric betaine as stated on product information as well as synthetic intermediates, side products, and/or breakdown products of these and conclude that this suggests impurities in surfactant concentrates as origin. They also state that different products from a single supplier contain different original substances.

The analytical results focussed on products used by professionals. No similar study is available for usage in hand-held fire-extinguishers which are on the market for consumers. Chemours recommends two products Capstone 1430 and Capstone 1440 for use in portable extinguishers, both are characterised as "blend of partially fluorinated and hydrocarbon surfactants[32]".

3.1.2 Market information in surveys and reports

3.1.2.1 Identification of applications via monitoring of point sources

Environmental monitoring of point sources was used as an initial step to investigate and confirm uses that were established before the concerns related to PFAS were recognised. The information is complementary to production and application information and used as a starting point to investigate whether these uses are still in place currently. Moreover, emerging PFAS are identified were possible. The search strategy started with publications on monitoring results in locations downstream from production sites and known locations of open and large industrial applications.

Use of PFAS in firefighting foams caused contamination of soil and groundwater in particular near airports, large scale event of fire or training grounds. Studies related to the use of PFAS in firefighting foams were based on surface water and groundwater in potentially contaminated areas. PFHxA was detected in groundwater and surface water downstream from a military airport near Stockholm. The airport was decommissioned in 1994. It is unknown which precursors were used (Filipovic et al., 2015). The maximum concentrations for PFHxA was 900 ng/L in groundwater; PFOA in the same sample with high contamination was 4400 ng/L.

PFHxA was also detected in one contaminated private well downstream from a firefighting training area in Cologne. The concentration declined from 0.37 to 0.04 ng/L in the relatively

[32] https://www.chemours.com/Capstone/en_US/assets/downloads/capstone-1430-technical-information.pdf

short period between December 2009 and November 2010. No explanation is provided (Weiß et al., 2012).

Several studies investigated wastewater treatment plants (WWTP), riverine water and groundwater downstream from production sites. This can be seen as an indication of additional application areas, though the results need to be matched with direct product analysis.

A study by Clara et al. (Clara et al., 2008) compared PFHxA concentrations in effluents from industrial point sources and municipal WWTP and detected higher concentrations (maximum 280 ng/L) in WWTP effluents with diffuse sources compared to industrial sources. Industrial point sources included were printing industry, textile industry, laundry and cleaning industry, paper industry, electrical industry, and metal industry; with paper industry providing the highest concentration (180 ng/l).

Lin et al. (Lin et al., 2010) detected PFHxA in effluents from a semiconductor plant in Taiwan (Hsinchu City); the study includes also PFBS as a short-chain compound and several long-chain compounds. For PFHxA concentrations in the effluent of two municipal WWTP were higher (180 ng/L and 155 ng/L), compared to the industrial site (71.5 ng/L). For municipal WWTP also an increase of effluent concentration compared to influent concentration was detected, indicating inefficient removal and possible transformation of other compounds to PFHxA. Possible sources for PFHxA were not discussed by the authors. For PFBS, the values for municipal WWTP effluents were 16.3 ng/L and 3.3 ng/L, compared to 960 ng/L in the industrial source.

Several publications are available describing PFAS concentrations downstream from fluoropolymer manufacturing facilities in France. The location of the factories is not disclosed, descriptions indicate that one of it is potentially in Lyon. Dauchy et al. (Dauchy et al., 2012a, 2012b) describe two different production sites, one is a fluoropolymer production at which from 1960 to 1987 polytetrafluoroethylene (PTFE) was produced, and from 1981 to 1996, fluorinated copolymers were synthesized. These copolymers are used to improve the grease- and water-resistance of paper, cardboard, and textiles. The authors do not further specify products and applications related to release of PFHxA.

In the same industry area, polyvinylidenflouride (PVDF) production is believed to have started in 1981 (Dauchy et al., 2012a), contributing to emissions of PFNA. The release of PFNA and PFHxA was estimated to have been 10 tons/year and 4.5 tons/year, respectively. 10 PFAS were investigated in total, among them the short-chain PFBA, PFPeA, PFHxA and PFBS. PFBS was found in one out of five monitoring wells at the manufacturing plant with a concentration of 0.280 µg/L. The short-chain PFCA were found in all five wells, PFBA was found with concentrations between 0.009 and 0.274 µg/L, PFPeA with concentrations between 0.015 and 0.364 µg/L, PFHxA with concentrations between 0.154 and 20.6 µg/L. Drinking water wells located downstream from the manufacturing plant showed concentrations between 0.005 and 0.015 µg/L for PFBA, below 0.004 and 0.027 µg/L for PFPeA, 0.089 and 0.146 µg/L for PFHxA and below 0.004 to 0.004 µg/L for PFBS. Due to the long production history at the plant, the authors suggest it is not possible to identify specific products.

A second, independent production site was investigated for a similar range of PFAS (Dauchy et al., 2012b). At this site, a fluorotelomer polymer production plant is located. The product range includes firefighting foams and stain repellents for paper, carpets and textiles since the plant opened in 1996. Prior to 1996, another manufacturer occupied the plant, and perhaps also used or produced PFAS. PFBS was not found in a monitoring well at the manufacturing plant, but in a cumulative sample from the effluent of the wastewater treatment plant with concentrations of 0.11 µg/L for 24h sampling and 0.20 µg/L for 7d sampling, respectively. The short-chain PFCA were found in all five wells, PFBA was found with concentrations between 0.11 and 1.49 µg/L, PFPeA with concentrations between 0.41 and 4.50 µg/L, PFHxA with concentrations between 0.40 and 6.26 µg/L. Drinking water wells 15 km downstream were also investigated, only in one out of five wells were concentrations above the LOD of 0.004 µg/L: PFBA 0.007 µg/L, PFPeA 0.023 µg/L and PFHxA 0.021 µg/L. The authors comment that the pumped flow in this well was higher compared to others. PFBS was under LOD for all drinking water wells.

High concentrations of PFHxA (2300–16,000 ng/L) were also reported for a sampling site downstream from a fluororesin producer in the area of Osaka in Japan (Takemine et al., 2014). No specific information regarding the products is provided. Another example is a sampling site downstream from Jiangsu Hi-tech Fluorochemical Industry Park in Changshu, 70 km west of Shanghai with fluororesin for paint among the listed products[33]. Monitoring of environmental concentrations in Taihu Lake (20 km south of the industry park) revealed high levels in the north part which is close to potential sources such as fluoropolymer manufacturing as well as releasing of waste water (Guo et al., 2015). The reported values for surface water are for PFBA between under 0.6 ng/L and 4.06 ng/L, for PFPeA between under 0.5 ng/L and 6.06 ng/L, and for PFHxA between under 0.4 ng/L and 22.2 ng/L. Only a minor part of sediment samples showed PFCA, with 0.09 ng/g (dry weight) for PFBA, 0.11 ng/g (dry weight) for PFPeA and 0.34 ng/g (dry weight) for PFHxA as maximum values.

Monitoring of sources confirmed the precursors for PFAS have been used for different applications, it is however not possible to link degradation end-stage substances clearly to specific products and application areas.

3.1.2.2 Identified applications of short-chain PFAS from literature

Several application areas have been investigated by various authors via direct analysis of products or by analysis of emissions from samples and production sites. Among the identified relevant products are paper bags for micro wave popcorn, for which one study identified PAPs as a likely precursor. Coatings for non-stick cooking ware released PFAS mostly in overheating scenarios. Consumer products in which short-chain PFAS were found included textiles with waterproof and dirt repelling impregnation, such as outdoor clothes and equipment or carpets. High concentrations were found additionally in ski wax and impregnation or nano-sprays. An investigation of personal care products and sunscreen found short-chain PFAS in the majority of the samples. The ingredient lists included PAPs. AFFF were found to contain high concentrations, with 6:2 FTS and 6:2 FTOH also present in the samples. Surroundings of production sites in France, Japan and China showed contamination with short-chains PFAS in groundwater and surface water. The product range for the production site in France is given as PVDF (one site) and fluorotelomer products for applications in firefighting foams and stain repellents for paper, carpets and textiles. For the production sites in Japan and China, the information about products is only fluoropolymer resin with paint as a potential application.

3.1.2.3 Identification of documented uses, patents and statistics in publications

Publications evaluated thus far include original laboratory research and analytical results. Additional input was searched from publications and reports based on documented uses, patents, statistics and surveys compiled for publications and reports. For this type of information, it is to some extent possible to revisit (online) documents and compare the current status to what was documented earlier. A compilation of publications and reports is summarised in the following section.

[33] http://www.3f-cs.com/product_detail_en/id/13.html; Note: this is the English version of the company´s website, details are only provided in Chinese.

Documented uses of short-chain PFAS have been analysed by Wang et al., (Wang et al., 2014) who found that the historical uses of PFHxA and its derivatives remain unidentified. Mapping of sources and pathways is ongoing and not complete. For PFHxA and PFBA (and PFBS) limited data are available, such as: [i] production/import ranges in the US in some years; [ii] historical use of PFBA; [iii] current use of PFHxA and some derivatives. But the authors identify gaps for [i] chemical compositions and other use; [ii] volume of production and emissions; [iii] PFCA homologue compositions. Available data only provide information for a sum including PFHxA, PFOA and more compounds.

According to Wang et al. (Wang et al., 2014), some fluoropolymer or fluoroelastomer producers may have started recently to use PFHxA-derivatives to replace PFOA and PFNA as processing aids in the polymerization process. This assumption is based on a patent (Matsuoka et al., 2010) and also consistent with results discussed in relation to monitoring of point sources in France, for which the authors indicate that wastewater with high concentrations of PFHxA is released from a plant that uses relatively high levels of PFHxA to synthesize per fluorinated polymers (Dauchy et al., 2012a). Moreover, usage of PFHxA for polymer production is included in a synthesis paper published by the OECD (Organisation for Economic Co-operation and Development (OECD), 2013).

In addition, the authors report that the company Miteni in Italy has marketed PFHxA, and related compounds for use in surface treatment of glasses, natural stones, metals, wood, cellulose, cotton, leather and ceramics. A cross-check with the company website in 2017 showed that PFBA and PFHxA are listed under products as building blocks, additives for coatings and additives for polymers.[34] The company website is no longer active and Miteni filed for bankruptcy on October 31st 2018. The activities were assigned to WeylChem, where a link to fluorinated derivatives can be found on the company website. The linked product datasheets are not available[35].

Wang et al. (2014) additionally state that PFBA was in the past produced by 3M for use in photographic films, which ceased in 1998 due to decreasing customer demand.

Phosphorus-containing perfluorinated substances are reported in a few publications and have been observed first in Canada. An analytical study by Lee and Mabury found perfluorohexane phosphonic acid (PFHxPA) in serum samples and suggests that direct exposure to common household products, such as carpet and upholstery cleaners, and cleaning fluids for the bathroom as an explanation (Lee and Mabury, 2011). The authors indicate that perfluorophosphonates (PFPAs) and perfluorophosphinates (PFPiAs) are fluorinated surfactants used as levelling and wetting agents in waxes and coatings.

Wang et al. (Wang et al., 2016) suggest that C4/C4 PFPiA could potentially be used to replace long-chain PFCA and PFSAs. As a commercial brand name for a C4/C4 PFPiA product Tivida FL 2100 (Merck) is listed. Products available as of 2019 include Tivida FL 2200, Tivida FL 2300, for which the supplier claims that the perfluorinated chain lengths are C2 and C3[36].

Further commercial phosphorus containing products are mixtures, which potentially contain also short-chain substances. The brand names provided in this context by (Wang et al., 2016) are Fluowet PP (C6-C12 PFPAs and PFPiAs, brand name for Clariant), and Masurf FS-710,Masurf FS -

[34] http://www.miteni.com/Markets%20and%20applications/Performance%20Product%20List/index.html (Note: the link is no longer active, archived version https://web.archive.org/web/20170927013456/http://www.miteni.com/Markets%20and%20applications/Performance%20Product%20List/index.html)

[35] https://www.weylchem.com/advanced-intermediates.html

[36] https://www.merckgroup.com/de/brands/pm/tivida/tivida-fl.html

715MS and Masurf FS -780 (C6-C12 PFPAs and PFPiAs in aqueous solution, brand name for Mason /Pilot Chemicals.

A report for the Norwegian Environment Agency focussed on sources of PFBS in the environment (Norwegian Environment Agency, 2017). Main applications were identified for side-chain-fluorinated polymers in impregnating agents for leather (nubuck and suede), outdoor textiles and carpets; and for PFBS salts as flame retardants in (clear) polycarbonate. Moreover, the report indicated that PFBS-related substances may be found in coatings of articles for which the substances have been used as a surfactant, without a function in the article (Norwegian Environment Agency, 2017). The report indicates that company information was provided mostly by 3M. Miteni (Weylchem) and SABIC were also identified as producers but did not provide further information. For PFBS-K a number of products were listed including Miteni RM65 (links to fluorinated derivatives chemicals are deactivated on the website[37]); 3M FR-2025[38]; Lanxess Bayowet C4[39]; Mitsubishi Materials Electronic Chemicals KFBS[40]; Unibrom Ecoflame S-338[41]. Oceanchem does not have fluorinated flame retardants on the current website[42].

PFBS is provided by Mitsubishi Materials Electronic Chemicals for application as acid catalyst, raw material for ionic liquid and photo-acid-generator (PAG), synthetic raw material with the product name FBSA.

MeFBSA is listed in the report by (Norwegian Environment Agency, 2017) as an ingredient in low concentrations in surfactants provided by 3M (Novec FC-4430, Novec FC 4432) and as impregnating carpet treatment PM-1690. Moreover, an application as a surfactant in the manufacturing of synthetic leather is reported as PM-1000.

MeFBSE is listed as surfactant in paints (Novec FC-4430), in carpet treatment PM 1690, as repellent for porous hard surfaces Stain resistant additive SRC-220 and as tile grout additive (Protective material PM 803). Moreover, applications in manufacturing are listed as additive in extrusion of synthetic fibres (Repellent polymer additive PM 870) and as surfactant in the manufacturing of synthetic leather as PM-1000.

For MeFBSAC, similar applications are recorded, as an ingredient with low concentrations in surfactants for paints (Novec FC 4430, Novec FC 4432, Novec FC 4434); as repellent for fabric protective material PM 4950 and for the manufacturing of synthetic leather PM 1000. Additionally, application in solder is listed for Loctite FM 381M for the company Henkel. For tetrabutyl-phosphonium nonafluoro-butane-1-sulfonate, an application as antistatic additive for plastic is included. The listed product name ZONYL FASP-1 is not available at the supplier Chemours/DuPont.

Complimentary information from reports provides market information based on surveys including producers and brand names. Total tonnages and concentrations in applications are not listed. A Swedish survey on occurrence and use of highly fluorinated substances and alternatives from 2015 (KEMI, 2015a) included also information about short-chain PFAS for a number of application areas.

[37] https://www.weylchem.com/advanced-intermediates.html

[38] http://multimedia.3m.com/mws/media/774720O/3m-flame-retardant-additive-fr-2025.pdf

[39] https://lanxess.com/en/corporate/products-solutions/product-search/bayowet-c4/

[40] http://www.mmc-ec.co.jp/eng/product/perflu.html

[41] http://www.unibrom.com/Public/Uploads/EcoFlame-S-338(1).pdf

[42] http://www.oceanchem-group.com/fr.aspx#undefined

For application as impregnating agent on textiles and leather 3M developed a number of surface treatment products that were side-chain fluorinated polymers based on derivatives of perfluorobutane sulfonyl fluoride (PBSF) with four perfluorinated carbons. Examples of product names are Scotchguard PM-3622 (CAS number 949581-65-1), PM-490 (CAS number 940891-99-6) and PM-930 (CAS number 923298-12-8). Amounts in use are not provided by the survey. There are also examples of fluorotelomers that are used as alternatives, primarily those based on six perfluorinated carbons. These contain copolymers based on 6:2 fluorotelomers and polyfluorinated siloxanes. The company Miteni has launched polyfluoroalkyl alcohols (5:1 and 3:1 FTOH, CAS numbers 423-46-1 and 375-01-9) that can be used as building blocks for side-chain fluorinated polymers. No information is provided on tonnage and actual applications.

For food packaging, the survey confirms the use of PAPs/diPAPs and lists also side-chain fluorinated polymers, pointing out that these are mainly based on 6:2 fluorotelomers.

For firefighting foams, 6:2 FTS and dodecafluoro-2- methylpentan-3-one (3M Novec 1230) are listed as main function providing components, while also stating that for a large part of products no information is provided since this is considered to be confidential business information.

For paints and printing ink, a variety of raw materials is listed in the survey, with a trend to shorter chain lengths mentioned. The potential substances are not completely specified: Short-chain fluorotelomer-based surface-active substances (Capstone ©), C4-compounds based on PFBS and fluorinated polyethers for paints. For printing inks, isomer mixtures with a range that cover short and long-chain PFAS are listed, including poly/perfluorinated ethers, and fluorinated (meth)acrylate polymers (C6).

In electronic equipment, according to producers the potassium salt of PFBS (CAS number 29420-49-3) is used as a flame retardant in polycarbonate resins. Other isomer mixtures with short-chain and long-chain PFAS are listed.

A literature study for the Danish EPA investigated short-chain PFAS in particular (Danish Ministry of the Environment, 2015). The study suggests that uses are impregnation, firefighting foams, metal plating, oil production and food packaging.

3.1.3 Information search in databases

Registration data for chemicals is available for the Nordic countries for the period from 2000 onwards via the database SPIN, and for the European Union via the REACH pre-registration and registration databases.

3.1.3.1 Information from databases

The database SPIN[43], short for substances in preparations in the Nordic countries, is based on registries for Denmark, Finland, Norway and Sweden and contains a total of 28583 records[44]. Information is provided for the number of registrations and amount in tonnes per year and country. Companies are obliged to report notifiable chemical products if they are manufactured in Sweden or imported or transferred into Sweden to the Swedish Chemicals Agency (KEMI). If the annual volume per product is at least 100 kg, companies must also report the products and the amounts. Notifiable products are identified based on their custom tariff numbers. Similar registers are implemented in Denmark, Norway and Finland and the results are collected in the

[43] http://spin2000.net/

[44] As of March 2019

SPIN database. It is not known whether the registration criteria are fully aligned. The description above is taken from KEMI, other authorities do not provide information in English[45].

The most recent records (accessed in March 2019) cover the year 2016. A survey by the Swedish Chemicals Agency indicated that the public database in its current form is limited for following up PFAS and other specialty chemicals that are not used in large amounts, and a future update is planned to consider that. Substances with confidential tonnage data are listed as records only, the tonnage is not revealed.

A mapping of entries in the SPIN database and the REACH pre-registration data found in 2013 (Posner et al., 2013) 118 CAS numbers related to per- and polyfluorinated substances, which included all chain lengths. The list was revisited to identify a subset of short-chain substances and add information of potential usage in the Nordic countries from SPIN and in the EU from the database of registered substances. The list collected by Posner et al. (2013) included also a number of mixtures, for which the chain length is not precisely known. Those substance groups were included where the lower chain length was below or equal six, even if the upper chain length was longer than six.

Substances/mixtures which have been identified as short-chain PFAS or mixture that contains short-chain PFAS and are registered in the Nordic countries are listed in the following table. For substances that are not marked as confidential an indicative tonnage is provided for the entire period that is inventoried in the SPIN database. The year given in the column ”newest entry” refers to the year when a preparation was last registered with a volume. Newer records might be available but are marked as confidential. Where available, use codes have been retrieved from the database and included in Table 17. For some entries that were marked as confidential it was still possible to identify a use code.

Table 17: short-chain PFAA and precursors listed in the SPIN database; accessed February 2019

Name/Acronym	CAS No	total amount 2000-2016 in tonnes	Newest entry with preparations> 0.1 %	Use code
Potassium 1,1,2,2,3,3,4,4,4-nonafluorobutane-1-sulphonate (PFBS-K)	29420-49-3	Confidential	-	-
Potassium perfluoropentane-1-sulphonate (PFPeS-K)	3872-25-1	Confidential	-	-
Perfluorovaleric acid (PFPeA)	2706-90-3	Confidential	-	-
Undecafluorohexanoic acid (PFHxA)	307-24-4	Confidential	-	-
Hydrofluor Ether	163702-08-7	8.5 (cleaning/washing agent)	2016; all non-confidential entries are for Finland; 3M Novec Engineered fluid HFE-7100	Cleaning/washing agents; solvents

[45] https://www.kemi.se/en/products-register

Name/Acronym	CAS No	total amount 2000-2016 in tonnes	Newest entry with preparations> 0.1 %	Use code
1,1,1,2,2,3,3,4,4-nonafluoro-4-methoxybutane	163702-07-6	8.6 (cleaning/washing agent)	2016; all non-confidential entries are for Finland; 3M Novec Engineered fluid HFE-7100/Cosmetic Fluid CF 61	Cleaning/washing agents; solvents; lubricants and additives
1-ethoxy-1,1,2,3,3,3-hexafluoro-2-(trifluoromethyl)propane	163702-06-5	0.2 (cleaning/washing agent)	2016, all non-confidential entries are for Finland	Cleaning/washing agents; solvents; lubricants and additives
1-ethoxy-1,1,2,2,3,3,4,4,4-nonafluorobutane	163702-05-4	0.2 (cleaning/washing agent)	2016; all non-confidential entries are for Finland	Cleaning/washing agents, solvents
2-[methyl[(nonafluorobutyl)sulphonyl] amino]ethyl acrylate (MeFBSAC)	67584-55-8	0	2016	Surface treatment; Impregnation materials
4:2 Fluorotelomer alcohol (3,3,4,4,5,5,6,6,6-nonafluorohexanol)	2043-47-2	Confidential	-	-
6:2 fluorotelomer alcohol (3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctan-1-ol)	647-42-7	Confidential	-	
6:2 fluorotelomer sulfonic acid (3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctanesulphonic acid)	27619-97-2	0	2016; all non-confidential entries are for Finland	Conductive agents; Surface treatment
6:2 Fluorotelomer sulphonamide N propylmethyl betaine (Carboxymethyldimethyl-3-[[(3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl)sulphonyl]amino]propylammonium hydroxide)	34455-29-3	17 (Flame retardants and extinguishing agents)	2015; Sweden	Flame retardants and extinguishing agents
6:2 fluorotelomer acrylate	17527-29-6	Confidential	-	-
6:2 fluorotelomer methacrylate	2144-53-8	Confidential	-	-
C6-C12 PFPAs	68412-68-0	>4,33 tons (no match for year and use code)	2009	Pesticides, agricultural; cleaning/washing agents

Name/Acronym	CAS No	total amount 2000-2016 in tonnes	Newest entry with preparations> 0.1 %	Use code
C6-C12 PFPiAs	68412-69-1	>3,33 tons (no match for year and use code)	2014	Pesticides, agricultural
Carbamic acid, (4-methyl-1,3-phenylene) bis-, bis(2-(ethyl((perfluoro-C4-8-alkyl) sulfonyl)amino)ethyl) ester	68081-83-4	Confidential	-	Comment: included as indirect PFOS precursor in an assessment by NICNAS
Silane, triethoxy(3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl)-	51851-37-7	Confidential	-	-
Thiols, C4-10, γ-ω-perfluoro	68140-18-1	Confidential	-	-
Thiols, C4-20, γ-ω-perfluoro	68140-19-2	Confidential	-	-
Thiols, C6-12, γ-ω-perfluoro	68140-20-5	Confidential	-	-
Butanoic acid, 4-[[3-(dimethylamino)propyl]amino]-4-oxo-, 2(or 3)-[(γ-ω-perfluoro-C6-20-alkyl)thio] derivs.	68187-25-7	Confidential	-	-
1-Propanesulfonic acid, 2-methyl-, 2-[[1-oxo-3-[(γ-ω-perfluoro-C4-16-alkyl) thio]propyl]amino] derivs., sodium salts	68187-47-3	24.1 (Flame retardants and extinguishing agents)	2016; non confidential entries are for Sweden	Flame retardants and extinguishing agents
1-butanesulfonamide, 1,1,2,2,3,3,4,4,4-nonafluoro-N-methyl((MeFBSA)	68298-12-4	Confidential	-	-
Sulfonic acids, C6-12-alkane, perfluoro, potassium salts	68391-09-3	Confidential	-	-
1-Propanaminium, 2-hydroxy-N,N,N-trimethyl-, 3-[(γ-ω-perfluoro-C6-20-alkyl)thio] derivs., chlorides	70983-60-7	Confidential	-	-
Perfluorocompounds, C5-18	86508-42-1	Confidential	-	cleaning/washing agents
Sulfonamides, C4-8-alkane, perfluoro, N-(hydroxyethyl)-N-methyl, reaction products with epichlorohydrin, adipates (esters)	91081-99-1	Confidential	-	Comment: included as indirect PFOS precursor in an assessment by NICNAS
Imidazolium compounds, 2-C4-8-alkyl-3-(2-carboxyethyl)-4,5-dihydro-1-(hydroxyethyl), hydroxides, sodium salts	70983-60-7	Confidential	-	Comment: included as indirect

Name/Acronym	CAS No	total amount 2000-2016 in tonnes	Newest entry with preparations> 0.1 %	Use code
				precursor of long-chain PFCA in an assessment by NICNAS
Sulfonamides, C4-8-alkane, perfluoro, N-(hydroxyethyl)-N-methyl, reaction products with epichlorohydrin, adipates (esters)	91081-99-1	Confidential	-	Comment: included as indirect PFOS precursor in an assessment by NICNAS

A majority of the entries provided only confidential information. Larger tonnages are reported for ether compounds, CAS No 163702-08-7, CAS No 163702-07-6, CAS No 163702-06-5 and CAS No 163702-05-4 for which the use cleaning/washing agent is recorded. For several mixtures of phosphorus-containing substances tonnages are reported. It is however not possible to identify a usage for any of the year and country combinations in the SPIN database. For Sweden a usage of PFPiAs as pesticides is reported, albeit without a corresponding tonnage entry. For Sweden also a usage of PFPAs as pesticides is recorded, for Norway a usage as cleaning agents.

The entry with the highest tonnage of approximately 24 tonnes is for an alkyl amine derivative, CAS No 68187-47-3. The usage is recorded as flame retardants and extinguishing agents. For 6:2 fluorotelomer sulphonamide N propylmethyl betaine, CAS No 34455-29-3 with a tonnage of 17 tonnes also a usage as flame retardants and extinguishing agents is recorded. For 2-Propenoic acid, 2-[methyl[(nonafluorobutyl) sulfonyl]amino]ethyl ester (MeFBSAC, CAS No 67584-55-8) a number of registrations are listed for several Nordic countries and for several years with the newest entry for 2016. The use categories are surface treatment and impregnation materials. Several entries are listed as confidential; where a tonnage is provided, it is 0.0 tonnes, indicating a volume below 100 kg.

All entries were also included in a search using the Global Portal to Information on Chemical Substances (eChemPortal) provided by the OECD, which serves as a portal collecting information from databases globally. Databases that were accessed through this portal included reports to the Australian NICNAS Inventory Multi-tiered Assessment and Prioritisation (IMAP) framework, results are indicated in the table. Mixtures that include a number of chain lengths, are included in IMAP reports for longer chain varieties.

A cross-check of the entries found by Posner et al. (2013) with the REACH registration database and the database of pre-registered substances in March 2019 did reveal a list of substances for which a registration dossier has been prepared, but also that for a number of substances no further action towards registration has been recorded at ECHA (see Table 18). The pre-registration database was last updated on 07 February 2018 according to the information provided on the ECHA website. No further information is provided for substances that were initially entered in the pre-registration database and for which no registration dossier has been submitted subsequently. The expected deadlines for most of the substances with status „pre-registration“ were in 2010 and 2013. For Hydrofluor Ether (CAS 163702-08-7), 1,1,1,2,2,3,3,4,4-nonafluoro-4-methoxybutane (CAS 163702-07-6) and Perfluorocompounds (CAS 86508-42-1) the deadlines were in May and June 2018.

Table 18 gives an overview on the registration status of short-chain PFAS as published on the ECHA website. Substances for which the pre-registration deadline ended in 2010 or 2013 are compiled in Table 22 in Appendix B. For two substances, the pre-registration had been extended to May and June 2018, which was after the last update. No further information is available for these cases. For substances that are labelled as “intermediate use only”, volumes are not provided. Registrants are included in the list, the information on potential usage is however limited.

Table 18: Registered and pre-registered short-chain PFAS and mixtures containing short-chain constituents as published on the ECHA website

Name/Acronym	CAS No	REACH registration (status March 2019)	Registrant information
1,1,2,2,3,3,4,4,4-nonafluorobutane-1-sulphonic acid (PFBS)	375-73-5	1-10 tonnes/year	Registrant Momentive Performance Materials GmbH
Potassium 1,1,2,2,3,3,4,4,4-nonafluorobutane-1-sulphonate (PFBS-K)	29420-42-9	100-1000 tonnes	Registrants 3M, Lanxess, Miteni
tetrabutyl-phosphonium nonafluoro-butane-1-sulfonate	220689-12-3	+1 tonne/confidential	Registrants Miteni, SABIC
1,1,2,2,3,3,4,4,4-nonafluoro-N-(2-hydroxyethyl)-N-methylbutane-1-sulphonamide (MeFBSE)	34454-97-2	10-100 tonne	Registrant 3M
2-[methyl[(nonafluorobutyl) sulphonyl]amino]ethyl acrylate	67584-55-8	100-1000 tonnes	Registrant 3M
3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctanesulphonic acid	27619-97-2	10-100 tonnes	Registrant Chemours (NL)
Potassium 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctanesulphonate	59587-38-1	0-10 tonnes	Registrant Chemours
Carboxymethyldimethyl-3-[[(3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl)sulphonyl]amino]propylammonium hydroxide	34455-29-3	100-1000 tonnes	Registrant Chemours
3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl acrylate	17527-29-6	100-1000 tonnes	Registrants Archroma, Chemours NL, Daikin
3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl methacrylate	2144-53-8	100-1000 tonnes	Registrants AGC Chemicals, Archroma, Chemours NL, SCAS
Trichloro(3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl)silane	78560-45-9	10-100 tonnes	Registrant EVONIK

Name/Acronym	CAS No	REACH registration (status March 2019)	Registrant information
tetraethylazanium nonafluorobutane-1-sulfonate	25628-08-4	0-10 tonnes	Confidential
Triethoxy(3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl)silane	51851-37-7	10-100 tonnes	Registrant EVONIK
Ammonium perfluorohexanoate	21615-47-4	10-100 tonnes	SCAS Europe
1,1,2,2,3,3,4,4,4-nonafluorobutane-1-sulphonyl fluoride	375-72-4	Intermediate use only, no tonnages	Registrants 3M, Lanxess, Miteni
2,2,3,3,4,4,5,5-octafluoropentan-1-ol	355-80-6	Intermediate use only, no tonnages	Registrants Central Glass Germany GmbH, Organica Feinchemie Wolfen
1,1,1,2,2,3,3,4,4,5,5-undecafluoro-5-iodo	355-43-1	Intermediate use only, no tonnages	Registrants Archroma, SCAS Europa
3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctan-1-ol	647-42-7	Intermediate use only, no tonnages	Registrants Archroma, Chemours
1,1,1,2,2,3,3,4,4,5,5,6,6-tridecafluoro-8-iodooctane	2043-57-4	Intermediate use only, no tonnages	Registrants Archroma, Chemours
Thiocyanic acid, 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl ester	26650-09-9	Intermediate use only, no tonnages	Registrant Chemours
Alkyl iodides, C6-18, perfluoro	90622-71-2	Intermediate Use only, no volumes	Registrant Archroma
1,1,1,2,2,3,3,4,4-nonafluoro-4-methoxybutane	163702-07-6	Pre-registration; deadline May 2018	No entry
Hydrofluor Ether	163702-08-7	Pre-registration; deadline June 2018	No entry

For substances for which a registration dossier has been submitted tonnages and registrants are provided, unless the substance is identified as „intermediate use only“, in which case information on registrants is available, but no tonnage information.

For registered substances with tonnage a search in the eChemPortal was carried out to identifyadditional information on usage and application from other sources. The Australian agency NICNAS indicates that PFBS is used for impregnation of textiles, leather and carpets; for industrial and commercial cleaning products; surface coatings, paint and varnish; oil production and mining; semiconductor industry; and electroplating. All usage information refers to literature that focused on alternatives to PFOS (Poulsen et al., 2005).

Potassium PFBS is marketed as a flame retardant for polycarbonate resins (Organisation for Economic Cooperation and Development (OECD), 2013).

The limited available information indicates that ammonium PFHxA could be used as a replacement for ammonium perfluorooctanoate in manufacturing fluorotelomers (Wang et al., 2013).

Several substances are included in an IMAP report on indirect precursors of short-chain perfluorocarboxylic acids (PFCA). Fluorotelomer alcohol and methacrylate monomers (CAS Nos. 647-42-7, 2144-53-8, 1799-84-4) are used as intermediates in the manufacture of polymers with fluorinated side-chains. In particular the 6:2 fluorotelomer derivatives have been selected to replace 8:2 fluorotelomer chemistry, and therefore are expected to have significant use. 2,2,3,3,4,4,5,5-octafluoro-1-pentanol (CAS No. 355-80-6) also has been identified for use as a chemical intermediate. Methyl perfluorobutyl ether has reported cosmetic use as a solvent and viscosity controlling agent[46].

For 6:2 Fluorotelomer sulfonate derivatives the IMAP report indicates that polyfluorinated betaine (CAS RN 34455-29-3) is reported to have use in firefighting foams, referring to literature (Place and Field, 2012).

A report on 6:2 Fluorotelomer siloxanes and silicones assessment includes Trichloro (3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl)silane (CAS 78560-45-9) and Tridecafluoro octyltriethoxysilane (CAS No 51851-37-7). The report refers to literature and product information provided by EVONIK for the DYNASYLAN brand and indicates a number of applications of tridecafluoro octyltriethoxysilane, such as treatment of automotive glass ("wiperless windshield"); easy-to-clean, water-repellent, UV-resistant coating of float glass (constructive glazing); additive for sol-gel systems; synthesis of fluorosilicones; coating of pigments; chemical vapour deposition (CVD) processes; and easy-to-clean coating on ceramics. EVONIK is the registrant for the above mentioned substances according to the REACH database. Moreover, tridecafluoro octyltriethoxysilane) is included as a binding additive in cosmetics (CosIng database). Some 6:2 fluorotelomer silanes or siloxanes (e.g. CAS No 51851-37-7 and 85857-17-6) are used in nanofilm spray products on surface coatings with non-stick properties, which are applied to surfaces such as bathroom tiles, floors, windows and textiles (Danish Ministry of the Environment, 2015).

3.1.4 Fluorine free alternatives

A number of fluorine free alternatives for different uses are reported in KEMI (2015a) based on information collected for the Stockholm convention on persistent chemicals, OECD, and the Danish environmental agency. The list does not differentiate whether this is an alternative to a long- or short-chain PFAS (Table 19).

Table 19: Fluorine free alternatives for different uses, summarised in (KEMI, 2015a) with further additions from (BAT/BEP Group of Experts, 2017)

Group	Uses
Propylated aromatics (naphthalenes/biphenyls)	Water-repellent agents for rust prevention systems, marine paints, surface treatments, etc.
Fatty alcohol polyglycol ether sulfonates	Levelling and wetting agents
Sulfosuccinates; Silicone polymers.	Levelling and wetting agents; Wetting agents and dispersants in paints and the surface treatment industry; Surfactants for the impregnation of textile

[46] https://www.nicnas.gov.au/chemical-information/imap-assessments/imap-group-assessment-report?assessment_id=1812

Group	Uses
	fabrics, leather, carpets, rugs and upholstery and similar articles; Wood primers and printing inks
Surface-active hydrocarbons	Photographic industry
Siloxane and silicone polymers	Impregnation of textiles, leather and carpets or surface treatment Wetting agents in the paint and ink industries Cleaning agents, polish and car wax Anti-foaming agents; Photographic industry
Stearamidomethyl pyridine chloride	Impregnation of all-weather textiles, leather and carpets
Polypropylene glycol ether, amines, sulphates	Levelling and wetting agents Decorative chrome plating, etc.
Polypropylene glycol ethers	Levelling and wetting agents for Decorative chrome plating, etc.

3.1.5 Complementary information in the guidance document on best available techniques and best environmental practice

Several databases and sources refer to the document "Guidance on best available techniques and best environmental practices for the use of perfluorooctane sulfonic acid (PFOS) and related chemicals" listed under the Stockholm Convention on Persistent Organic Pollutants, published in 2017 (BAT/BEP Group of Experts, 2017). The document summarises and updates results collected through studies and reports provided from national authorities including the analysed reports from several countries in previous years and contributes to mapping of the state of the art. Though the title implies a focus on PFOS, the information is relevant as among the alternative substances discussed here are fluorinated alkyl sulfonyl substances and polyfluorinated alkyl substances, for which perfluorinated alkyl substances with shorter chain might be end-stage metabolites. Additionally, fluorine free alternatives are listed.

In the following sections, information for applications that have not been identified in other reports are summarised. According to the cited reference, data were collected from literature and general internet search in 2016. Updates of links and additional information search have been carried out as part of a survey in December 2017. Note that "alternative substances" in this document are alternatives to long-chain PFAS, and the composition is often considered as trade secret. The applications described here include therefore potentially areas where short-chain PFAS are or will be increasingly used, in particular if there are no fluorine-free alternatives. The following product groups are included in the guidance document (BAT/BEP Group of Experts, 2017) and have not been identified in other studies. They are included here based on limited information for the sake of completeness.

3.1.5.1 Photo-imaging

Possible substances used for the photographic industry are C3- and C4-perfluorinated compounds. Fluorine free alternatives are hydrocarbon surfactants and silicone products. No specific trade names or other product specific details have been reported (BAT/BEP Group of Experts, 2017).

3.1.5.2 Aviation hydraulic fluids

Information on usage is limited and not conclusive; the report indicates that aviation hydraulic fluids based on fire resistant alkyl and/or aryl phenyl phosphate esters may contain additives such as potassium decafluoro(pentafluoroethyl)cyclohexanesulphonate (CAS 67584-42-3). The total global market for fluorinated compounds in aircraft hydraulic fluids is estimated to be about 2 tonnes per year. Annual fluorinated compound consumption in the European Union for this use was about 730 kilogram/year in 2000 (BAT/BEP Group of Experts, 2017). No further information regarding the chain length of substances that are actually applied is provided. Fluorine-free alternatives and technologies are not listed.

3.1.5.3 Metal Plating (hard metal plating)

For metal plating, wetting agents based on 6:2 FTS- are used widely. The following products are mentioned in the guidance document (BAT/BEP Group of Experts, 2017), but the market is developing.

6:2 Fluorotelomer sulfonate (6:2 FTS) based products and producers:

- ANKOR® Dyne 30 MS (Enthone)
- ANKOR® Hydraulics (Enthone)
- ANKOR® PF1 (Enthone)
- Fumetrol® 21 LF 2 (Atotech)
- HelioChrome® Wetting Agent FF (Kaspar Walter Maschinenfabrik GmbH & Co. KG)
- PROQUEL OF (Kiesow Dr. Brinkmann)

For a number of alternatives, no information on chemical composition is provided, it is therefore not possible to conclude whether they are fluorinated or fluorine free.

- Chromnetzmittel LF (CL Technology GmbH)
- Netzmittel LF (Atotech)
- Non Mist-L (Uyemura)
- RIAG Cr Wetting Agent (RIAG Oberflächentechnik AG

3.1.5.4 Metal Plating (decorative plating)

For decorative plating a shift to other electrolytes that are CrIII based are suggested. This would mean that the demand on surfactants and process fluids is considerably lower, and that PFAS are not required. For processes that use CrVI-based electrolytes, the products listed above for hard metal plating are basically applicable and some products can be found for both areas in the guidance document. However, suppliers choose whether to offer their product only for one of the two applications; therefore the lists are not identical.

6:2 Fluorotelomer sulfonate (6:2 FTS)-based products:

- ANKOR® Dyne 30 MS (Enthone)
- Cancel ST-45 (Plating Resources, Inc.)

- FS-600 High Foam (Plating Resources, Inc.)
- FS-750 Low Foam (Plating Resources, Inc.)
- Fumetrol 21 (Atotech)
- SLOTOCHROM CR 1271 (Schlötter Galvanotechnik)
- UDIQUE® Wetting Agent PF2 (Enthone)

Other fluorinated substances, but no information on chemical nature is known

- Chromnetzmittel LF (CL Technology GmbH)

3.1.5.5 Chemically driven oil production

Perfluorinated surfactants are used in the oil and gas industries to enhance oil or gas recovery in wells, as evaporation inhibitors for gasoline, such as jet fuel and hydrocarbon solvents. Moreover a use as surfactants in old oil fields in some regions to recover oil trapped in small pores between rock particles is reported. As an example for short-chain PFAS, the report (BAT/BEP Group of Experts, 2017) refers to:

- PFBS-based substances, such as 3M Gas Well Stimulant WS 1200 (see SDS at: http://multimedia.3m.com/mws/mediawebserver?mwsId=SSSSSuUn_zu8l00xmxtG58mvlv70k17zHvu9lxtD7SSSSSS--).

Alternative technologies exist but are not detailed.

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3.2 IT based online survey in short-chain PFAS

3.2.1 Organisation of the survey

The survey was planned and set up in the open source survey tool “Lime Survey” hosted by an external service provider. The tool was accessible via a web interface. The survey was conducted from 15th February 2018 until 15th April 2018. The original plan was to run the survey only for one month but due to several reactions from stakeholders it was extended by another month.

It was highlighted to provide information on all the use cases known (also if only small tonnages of a substance are applied) to avoid unintended consequences for market actors when a regulatory measure is implemented. Furthermore, it was pointed out that it would be of high importance to identify uses that might contribute to a high added value of products or have a high socio-economic value due to particular application (e.g. health care or pharmaceuticals).

Uses were also of particular relevance if they are linked to long phase-out periods of substances (for example due to long product development cycles, a long service life or safety related approval processes, that require longer transition periods for the phase-out of substances).

The survey could be accessed via the Ökopol website. The participants had to register themselves to participate in the survey. Different to the first survey, there were five separate surveys that made the distinction between the roles already clear before starting the survey. This measure had simplified the survey design by far. It also enabled the participants to access various questionnaires if more than one role applied to them. Roles that were offered were:

- For substance manufacturers
- For formulators of mixtures
- For end users of substances or mixtures
- For importers of substances, mixtures or articles, as well as article assemblers in the EU (that do not apply a mixture to an article)
- For associations, NGOs or other interested third parties

The survey was divided into four question groups:

- Which substances are relevant for your organisation?
- How are processes performed in your organisation?
- What might be the economic consequences on your organisation and to what extend do you see a possibility for substitution?
- How do you in general evaluate a restriction?

3.2.2 Follow up interview process

A follow up interview process was planned to generate additional information, fill data gaps and clarify open issues that might arise from the IT based survey. Many companies contacted Ökopol immediately when the IT based survey started and indicated they would prefer an interview or even more a face-to-face meeting to be able to discuss issues personally. Therefore, Ökopol held a number of meetings often followed by additional phone calls and e-mail exchanges. Upon these, additional documents and information were often provided.

As a general observation one could conclude that this is a preferred way for companies to liaise in regulatory activities. Many companies expressed the need to understand the background of the information collection in more detail. Important points in this regard were always:

- What happens to the data we provide?
- At what stage is the regulatory process and can we still influence it with the contribution?

- Are there any wider strategic regulatory plans by the authorities? What is the perspective for the substances under discussion in the mid/long term? (What is it industry can build business plans on?)

Especially the last question was a strong driver for some market actors to engage very intensively. In the field of fluorine chemistry there were some very specialised companies that see a general tendency of increasing regulatory activity, which brings high uncertainty for their business because they lack alternative business models. Their key competence is to produce fluorine-containing substances. This is often linked to highly specialised production infrastructure and their interest is often to understand under which conditions they can continue with their economic activities. Total bans of fluorochemistry would in consequence mean the end of relevant production capacity (in some extreme cases total end of corporate business). This can result in dramatic changes for an individual market actor, despite socio-economic considerations result in an overall benefit because it deals with the pros and cons of the proposed restriction on an overall EU market level and also takes into account opportunities for alternative producers. These market actors have a strong interest in protecting their business interest at least to a degree to which the company can continue to exist. This is one reason for the need to engage rather in direct exchanges with the researchers than to answer a formal survey.

The information provided via the interview process are included into the following chapters. They are shown in conjunction with aggregated findings from the survey.

3.3 Results from the survey and the subsequent interview process

3.3.1 General observations regarding participants

Overall, 98 organisations (companies, environmental and consumer NGOs associations) have participated in the online survey and the subsequent interview process. Sometimes, associations submitted information on behalf of a sector or a number of companies. Some organisations registered to the survey, but in the end, they did not provide any information via the tool or at all. Some organisations preferred to provide information via the direct submission of documents (e.g. via e-mail, via download from secured internet spaces).

Main sectors that contributed were:

- Chemical manufacturers/importers
- Formulators of chemical mixtures (textile, paper processing, printer inks and colours, surface treatment, firefighting foams)
- End users (mainly textile applications, firefighting foams, semiconductor industry)

Stakeholder roles were usually assigned by self-declarations by the participants. This was usually not questioned. For this report there was a reorganisation in one case, where an association declared itself a downstream user (DU), it represented DU-sector but was not one.

In the following, all information that was contributed are summarised. For manufacturers and importers, the information is provided by the role, since these market actors supply various sectors. For DUs and article producers/importers the information is shown by sector. The information described was provided by the companies that participated in the data collection. Only aggregated non-confidential data are shown in this report. In case only few companies responded ranges or magnitudes are given to give orientation for the research team, what the effect on a sector can be if a restriction will be introduced.

3.3.2 Manufacturers / Importers

Overall, 12 companies which assigned themselves to the group of PFAS manufacturers and importers contributed to the survey. These cover companies, which produce short-chain compounds, as well as companies which use these as intermediates or building blocks to synthesise larger polymeric substances. Some do both.

With regard to the tonnages of PFAS which are manufactured or imported it is important to take note of some sector specificities:

- The chemical processes are highly integrated. It is e.g. the case that one substance is only manufactured to produce one or several other substances.
- Resulting substances can more or less have the same tonnage (the molecule is only changed in details) or differ. The latter is often the case when a short-chain PFAS is used as a building block with other non-fluorinated compounds (e.g. when side chain fluorinated polymers are synthetized).
- This can either be done at the same facility (by the same company or another one that shares the plant with the producing company), or at another site (again by the same actor or another one).
- In the latter case the manufacturer or importer does not always know the subsequent routes (Was it a polymerisation, an intermediate use or was it formulated in a mixture for DUs?)
- As a consequence of the above mentioned aspects, it has to be stated that it is difficult to determine precise aggregated numbers for individual sectors. As a consequence, the presented data in this section should be seen as best estimates that show the order of the magnitude of the different use areas.
- It is assumed that US, Japan and EU based manufacturers are covered very well[47].
- It should be noted that although some of the key players from that sectors have contributed to the data collection, there might be larger players from Russia, China or India that also contribute to the EU tonnage.

Intermediates

As already indicated, a large share of the short-chain PFAS are further processed as intermediates. Main compound groups that are represented in that area are C6 iodides, alcohols and acrylates in several variations. They are placed on the EU market in an estimated amount < 10,000 tons per year (tpa). Again, it must be noted that large shares of this estimated tonnage represents an intermediate use where one C6 compound is just converted into another one. Only a small share of the different C6 substances is really used for generating polymeric compounds as a building block.

[47] For this regions on one known Italian manufacturer did not respond.

Direct use in polymer production

Direct uses of short-chain PFAS as emulgator in the production of fluoropolymers (no incorporation into the polymer molecule) have been reported in the information collection. It must be estimated to be far lower < 500 tpa.

Surfactants for wide range products

The use of PFAS in surfactants (not further specified) is a second area where PFAS on the basis of C6 PFAS are used – often in the form of polymers or co-polymers. Estimated amounts are in the range of < 500 tpa. Additionally, there are surfactants that are based on C4 PFAS. Estimated tonnage of such surfactants are < 200 tpa.

Typical application products that have been mentioned are:

- Wetting agents for water borne, solvent borne, high solids and radiation curable coatings
- Paints (including consumer paints)
- Adhesives (non-food contact)
- Clear coats
- Resins (non-food contact)
- Inks (non-food contact)
- Well stimulation

Surfactants for firefighting foams

One of the most relevant application areas are the firefighting foams. Surfactants placed on the market in that area are estimated to be in the range of 1500 – 3000 tpa. Responses in the information collection indicated that only C6 PFAS are used in this area (no C4 compounds). Producers claim that the use of fluorinated surfactants for high hazardous liquid fires is still without alternatives. Products that require these compounds are the aqueous film forming foams (AFFF) and alcohol resistant AFFF (AR-AFFF) products.

The risk of C6 PFAS is estimated to be lower compared to the former use of C8 chemistry due to its lower bioaccumulation potential and lower toxicity. Furthermore, producers claim that the substances can be handled in a safe way because the AFFF and AR-AFFF foams are usually only needed to be used at industrial sites. Such sites should be equipped with installations that can hold back the run-off water. This could then be collected and treated after the incident.

Paper

PFAS amounts placed on the market for treatment of paper are estimated to be < 300 tpa, used as fluorotelomer compounds.

Textile applications

For the treatment of textiles, the tonnage placed on the market by companies that were involved in the data collection is < 1200 tpa. Likewise, as in the case of paper applications the PFAS are used as fluorotelomers. Application areas are the treatment of non-woven fibres, finishing of produced textiles and as a sub-sector the treatment of carpets as a smaller application (<150 tpa estimated).

Hard surface treatments

This use covers the treatment of hard surfaces like e.g. stone, ceramics, tile ground etc. with either solvent or aqueous based fluorinated polymers solutions or dispersions to impact functional oil and water repellency. Such finishes are applied to the surfaces via spray, roller or brush applications and are available for industrial and professional users and for consumers, also. The estimated tonnage range for this application area is < 1000 tons per year.

3.3.3 Downstream users/article importers

In the following, the applications of the short-chain PFAS will be discussed. This will not be shown by the role of the market actors[48] but by the application areas.

The following market areas contributed to the information collection:

- coating additives and printing chemicals
- textile and leather finishing agents (oil, water, dirt repellents)
- fire extinguishing foam compounds
- digital and analogue imaging
- semiconductor industry

3.3.3.1 Coating additives and printing chemicals

Short-chain PFAS are used as surfactants in paints and varnishes as well as in special applications like printing inks. C4 or C6 PFAS have been introduced in this area as substitutes for the formerly used C8 substances. They are used in some special applications where water based mixtures are intended to be applied to very non-porous surfaces like e.g. plastic films. Here the main function in the mixtures is the reduction of the water surface tension, when the mixture is applied on nonporous substrates. In absence of a surfactant the mixture would tend to form large unequal drops that would lead to a non-uniform surface coverage of the paint, ink etc. Alternative technologies are solvent based or UV curable mixtures which are in the evaluation of one company. They are even less recommendable with regard to human health and environmental properties (during production and in final use).

Currently, non-fluorinated alternative surfactants do not provide similar performances. Substitution testing[49] by one company showed that out of 20 alternatives tested, only a C6 fluorosurfactant provided the intended performance. Another company also stated that C4 fluorinated compounds cannot be used.

With regard to printing inks, all activities on substitution were performed to meet the deadline to substitute the C8 chemistry until 2022. This means that currently used printers that rely on these inks as consumables will come to their service life end (expected to be between 7 to 10 years) and will need replacement. Research and development (R&D) work on the substitution of fluorinated surfactants was not successful in regard to finding a substitute that provided sufficient performance and ensured sufficient shelf life stability of the mixture (target: 2 years). It is therefore expected that a simple "drop in" substitution will not be possible but a more extensive reformulation will be necessary to develop competitive products. As a result of this

[48] The roles were often not clearly distinguishable. Several companies served as formulators for some mixture but were at the same time end users of these or other mixtures. More frequently there where some companies that were clearly end users of mixtures.

[49] This substitution testing was performed to substitute the formerly used C8 fluorosurfactant.

prognosis, it is not possible for those market actors to estimate the time needed to develop a fluorine-free alternative. Others estimate the time needed for substitution with 5 -10 years but are not giving an in depth rationale for this timeline. Regarding cost of substitution, some companies indicate similar ranges from 0.1 -10 million Euro. Others assume higher costs of > 10 Mio Euro. These estimations may vary with the company size and the speciality of the final application.

3.3.3.2 Textile and leather finishing agents (oil, water, dirt repellents)

Several companies that are using PFAS for the finishing of textiles or leather contributed to the data collection. Members of all supply chain levels contributed to the information collection. Some companies had several roles. There were companies involved that manufactured some substances they needed for the formulation of mixtures for textile finishing and were therefore substance manufacturer as well as formulators. The portion of in-house production varied between the companies. Some performed only the last steps of the textile finishing process while others preformed several preceding operations. Overall, 14 companies that are either formulating mixtures which contain fluorinated compounds or such that use them in finishing processes responded to the survey and/or were interviewed.

The products produced range from outdoor fashion, worker protection clothes, uniforms for the military, police etc. to textiles that are not intended for wearing by consumers but can be considered to be home textiles (e.g. carpets, awnings etc.) or are integrated in other products (e.g. aeroplane/car seats, automotive headliners). Other applications that can be included in this group of products are impregnation agents for leather. Furthermore, some special applications were reported, e.g. mixtures for the treatment of non-woven textiles for uses in the medical sector (chemical resistance of work wear in operating theatres) and non-woven for automotive sector (e.g. resistance of components in motor to oil and diesel/gasoline).

Direct use of lower molecular short-chain PFAS has not been reported. Fluorinated compounds are usually used as side chain fluorinated co-polymers (most reported are FTA). Fluorinated polymers seem to have a clear focus in the C6 chemistry. One formulator reported C4 fluorinated chemicals are not suited in the textile sector to meet the quality standards required. Application of the textile finishing agents can happen via various processes. These include padding (foulard, spraying, foam application, exhaustions or coating). The concentration of the polymers on the fibre was estimated by one submitter to be 0.3-0.5 % polymer solids on the fibre. Another submitter reported that residual free short-chain PFAS in the textiles produced are very low (if detectable at all):

- PFBS < 0.5 ppm
- PFBA < 0.025 ppm
- PFHxA < 0.025 ppm

Another company specified the residuals of other PFAS with:

- FTOH about 50 ppm
- PFC[50] (C<5) 50 ppm
- FTA 1 ppm

[50] This term has been used by the respondent and could not be further specified.

All participants clearly expressed the opinion that substitution currently is only possible for water repellence. Therefore, some companies agreed that for such cases consumer uses should potentially not be continued after a restriction. Others did not agree to this statement and tended to allow a continued use of fluorinated compounds for consumer uses also. One argument for a continued use was the limited washing durability of non-fluorinated finishings that would lead to shorter life cycles of the final products (2-5 years were mentioned) and would require that consumers buy new textiles after this period. This is seen as a disadvantage of alternatives, economically – e.g. consumers have to invest money for new products, as well as ecologically – recourse consumption for the production of new products.

Alternatives mentioned were compounds from the group of parrafines, siloxanes, melamines, polyurethanes and dendrines. As mentioned, none of them was seen as an alternative to provide sufficient oil and dirt repellence properties. Therefore, all respondents claim that following applications should be seen as essential:

- protection wear (e.g. uniforms, medical staff clothes)
- automotive (and similar e.g. like aviation)
- non-woven
- medical textiles

Companies often stated that emissions could occur via the water path. Usually, they state, this is not a direct emission but can occur as a carry-over from one production step into another. Direct production liquids and wash waters for cleaning installations are usually collected and disposed as waste. Several companies referred to the FluoroCouncil best environmental practice documents[51] as a reference for their processes.

The socio-economic impact on the companies that provided information varies with their role in the supply chain but also with their product portfolio.

Two companies that provided information had a strong focus and expertise in the field of fluoro-chemistry and were therefore highly specialised. Both companies synthetized several fluorinated compounds themselves and also produced some finished materials. They both had a turnover > 100 Mio Euro and over 95 % of this turnover with more than 250 employees active in fluorine-related activities. For these companies a restriction would lead to a need to change their current production practice fundamentally with a strong likelihood of not being able to continue this production in the EU. Other companies with similar roles (substance manufacturer, formulator and partly end user) were not so much impacted. Even if similar in turnover and employee numbers, the marketing of fluorinated compounds contributed less (in some cases 5-20 % in others < 5 %) to their net sales. These companies were also active in a wider range of market activities in the chemical sector and often also produced alternatives to fluorinated substances. In case they produced fluorinated and non-fluorinated solutions for textile applications they claimed the effort for the production of fluorinated substances to be higher (11-25 %) or the same (+/- 10 %) than for their non-fluorinated alternatives. This was different when a company bought the fluorinated substance and produced only the alternatives themselves. In this case the non-fluorinated substance impacted the cost for the product (a mixture that could be applied by an end user) at a higher degree.

[51] Guidance for Best Environmental Practices (BEP) for the Global Apparel Industry, Including Focus on Fluorinated Repellent Products https://fluorocouncil.com/innovations-stewardship/ (current version May 2014) available in English, German, Japanese and Chinese.

Companies that can be seen as end users of mixtures used in textile finishing relied usually less on the use of fluorinated compounds. Several of them reported that the share of products treated with PFAS only contributed < 5 % to their turnover. Other products with fluorine free alternatives often contributed in the same range or higher (one company 51 – 80 %). Only one end user relied very strongly on fluorinated compounds (> 95 %, alternatives < 5 %). Nevertheless, most companies stated that the products are important and substitution is currently technically not possible because the performance of alternatives is not sufficient. That was especially highlighted by companies that are not producing articles for consumer use. If such companies would be forced to substitute (regardless their performance concerns), they claim that at least 5 – 10 years would be needed to change production and the cost would be estimated to be > 10 Mio Euro (per company responded). Some other companies that produce with a stronger consumer focus in which water repellence is the most important feature (e.g. outdoor apparel) tend to envisage shorter transition periods (2-5 years) and lower costs (1-10 Mio Euro).

3.3.3.3 Paper

Information on the use of fluorinated substances is very scarce. Several requests to discuss the issue of a potential restriction were not answered by paper producers. The following information are based on information from two substance importers/manufacturers.

Typical features relevant for paper applications are (food contact material):

- Oil and grease resistance and durability
- Packaging materials for durable products: Oil repellence i.e. of pet food
- Reduced potential for burns from hot oil migration
- Maintains integrity and aesthetics of packaging material

It is claimed that potential alternatives for paper applications do not reach an equivalent performance. On the other hand the information collection on the long-chain PFAS in the frame of this project showed that a fast food company is in the process of substituting all fluorinated compounds from its packaging material. So at least partial substitution cannot be excluded (e.g. in the field of short term use and avoidance of oil migration). One of the companies reported that for other more durable paper applications, their aim is not to substitute a substance in the paper, but rather to apply different basic materials like e.g. plastics. Therefore, both companies claim that the continued use of fluorinated substances can also contribute to the substitution of plastics.

3.3.3.4 Fire extinguishing foam compounds

Main information on the firefighting foam were provided by the substance manufacturers. Responses from formulators echoed the input given from these market actors that for AFFF and AR-AFFF foams PFAS still cannot be replaced as alternatives do not meet the necessary standard.

3.3.3.5 Semiconductor industry

The semiconductor industry differs somewhat from other applications that make primarily use of the PFAS related surface activity (either as surfactant or as repellent). The use of PFAS as surfactant is only in one use relevant for this sector. Another use is the use of PFAS compounds as source of fluorinated acid for etching processes. In the following some details on the function are given. The overall amount of PFAS used in the sector can be assumed< 10 ton per year (based on a rough estimate on confidential consumption data provided by an individual company in the survey and the relatively low number of competitors in the EU market). Substances that are included meeting the definition of short-chain PFAS are fluorinated sulphuric compounds (C3 and C4) which were introduced as substitutes for PFAS and in expectation of future regulation of other PFAS with C6 chain lengths.

In the following, there are short general descriptions of the technical processes given where PFAS are of relevance. This information was provided mainly by one company but are considered more or less representative for all other companies within the sector.

Fluorinated compounds as surfactant

Surfactants in the semiconductor industry are used during the application of photoresists during the production process. They are applied in order to obtain an optimal coating with no disformations and/or adequate morphology and configuration for an optimized photo process.

Short-chain perfluorinated substances are used in very small quantities as ingredients at low concentrations in photoresist and ARCs (Anti-reflective coatings) chemical formulations in semiconductor photolithography. Short-chain perfluorinated substances are not becoming part of the final product (the microchip). They are exclusively used as a manufacturing processing chemical in very small quantities. Most photoresists and ARCs are solvent-based formulations that are drained separately into a solvent collection system. The related waste stream is treated off site via distillation to reclaim a major solvent constituent – the distillation residue is sent to incineration for thermal recovery. Some fraction of perfluorinated material may carry over from photolithography steps into subsequent development and/or cleaning processes and enter the waste water stream. One company claimed fluorinated derivatives are used at 100 – 300 ppm as an integral part of several lines of current commercial photoresists.

A fluorocarbon surfactant/surface modifier is much preferred to available alternatives because the known alternatives all contain silicon. Etching and ashing photoresist (subsequent steps in production of semiconductor wafers) convert the silicon to silicon dioxide, which is a difficult residue to remove and interferes with product quality.

Fluorinated groups in the photo-acid generator

Photolithography is the most important step in the production of semiconductor wafers.

- It shapes and isolates the junctions and transistors;
- it defines the metallic interconnects;
- it delineates the electrical paths that form the transistors;
- and it joins them together.

Photolithography is also integral to the miniaturisation of semiconductors. Miniaturisation makes integrated circuits smaller, cheaper, and faster and better, which is critical to continuing the electronic revolution. The introduction of imaging at 248 nm changed the way in which acidity of exposed, positive photoresist is altered. The shorter wavelength uses a mechanism called chemical amplification (to make the process more efficient).

Chemical amplification depends on a catalyst to chemically amplify the effect of the exposing light. The catalyst-precursor is called a photo-acid generator (PAG). A PAG is decomposed by light into an acid and the acid catalyses another reaction, which also produces an acid. This chain reaction continues to produce acid and leads to the positive photoresist being chemically transformed in the areas that have been exposed. The catalytic process is most effective when the photo acid produced from the PAG is a strong, Bronsted acid. This acid is preferably a sulphonic acid since it is one of the strongest acids. The acidity of sulphonic acid can only be increased by fluorinated substituents. Therefore, PFAS are used in PAGs because of its highly polar end's capability to trap hydrogen atoms liberated by PAG photolysis (creating very strong acids) when the PAG is exposed to light; its heavy, highly non-polar tail is allowing the molecule to stay in place within the mixture (anti-diffuser, highly soluble and non-agglomerating) such that uniform imaging only occurs where exposure takes place. Currently, PAG are based on PFBS or on other perfluorinated derivatives. Their use cannot be avoided. Other derivatives with the same technological properties are not yet developed. Other known PAG molecules tend to diffuse more than PFAS and/or are weaker acids and/or agglomerate (form particles).

Some alternatives to PFOS have been created, but are not necessarily useful in all applications (e.g. photoresists), nor in every use within an application (e.g. transistor contact layer versus upper metal/wire layers are very different technically). No single "drop-in" replacement is possible for all semiconductor applications where substitutes exist. Every use has to be re-engineered to see, if a replacement material will meet the technology requirements. Moreover, even within the semiconductor industry technologies are not consistent. Alternatives that work for one application, or one company, will not necessarily work for another application or another company. A company use of PFAS is in many areas of photoresists specific to their individual process.

The research on non-fluorinated substitutes requires the following approval steps

- adaptation of the chemical structure to the technological results expected (selection from a set of potential already discussed alternatives);
- confirmation of the good results in applications;
  - redesign of the formulation
  - control of the technological properties
  - adaptation of those new formulations to the customer infrastructure
  - standardisation of the R&D process to production

This substitution process takes also time and can only be done once the well-defined chemical structure, that is seen as the alternative, has been identified (hence, only after the step of a identification of a clear chemical alternative on a chemical level, real feasibility testing can be initiated). It is assumed this process will take more than 5 years. If no such substitute is found to be available, R&D will have to look for alternative chemistry or processes and the time period needed for an invention cannot be estimated.

Furthermore, the substance properties with regard to human health and environmental properties must be reviewed. Regarding the environment, it should be stated that almost all processes are performed without any emissions to wastewater or air. Only some fraction of perfluorinated material may carry over from photolithography steps into subsequent development and / or cleaning processes and enter the waste water stream. All waste is subjected to incineration and high destruction and removal efficiency has to be taken into account when estimating current releases. This is important to evaluate the impact on the environment. Based on the information available to the sector, all the waste of concern is sent to adequate waste facilities with high temperature incineration (higher than 1000°C).

Currently the semiconductor industry does not see an option to substitute the fluorine chemistry from their processes. Therefore, all companies that responded conclude, the uses should either be not included in the scope of a restriction or be specifically derogated.

3.3.3.6 Use of PFAS fluoroelastomer production

Two uses of PFAS have been reported in the production of fluorelastomers.

The first use is the application of a C6 PFAS in the manufacture of fluoroelastomers as emulsifying agent in the manufacturing process of the elastomers. The second is the use as curing end of C4 (PFBS) based compounds.

The second reported direct use of PFAS is the use as curative in the production of fluoroelastomers.

3.3.3.7 Other special uses of fluorinated compounds

A number of applications of fluorinated compounds have been reported in the information collection that do not completely fit in one of the areas described in more detail.

- One company reported that a side chain PFSA C6 product is used for the production in proton exchange membranes for the fuel cell industry. Here, currently no alternatives are known.
- One company uses perfluorpolyethers in an aerosol application during their in house quality control of other fluoropolymer products. They recognised that such laboratory applications might be sources of potential emissions (untreated off air) and will reduce these emissions in the future.
- One company uses polymethylacrylates in optical fibres, according to the company there are no alternatives available.
- One company uses C6 fluorosurfactants in the production of polyester films as anti-fog coatings for face shields for surgeons.
- One company uses fluorinated substances in special glass for:
  - Construction (external glazing and interior decorative glass)
  - Automotive (original and replacement glass)
  - Solar sector

This last-named company uses C6 fluorotelomer as oil and water repellent in the above mentioned applications. They are imported with the articles and the article contains 15-30 % of the compound (or a fluorine-free alternative). The fluorine containing products contribute to the company’s turnover to < 95 % and C6 has been introduced as substitute for C8, therefore no alternative is seen in short/mid-term. For some applications they see a potential for substitution by fluorine-free alternatives if only water repellence is needed (currently share < 5 % turnover). In other sectors they do not consider this option. In case a restriction would be implemented the company even sees a danger for increased risks in the health sector as the products are safety relevant. A substitution of all fluorinated compounds would be estimated in the range of > 10 Mio Euro.

3.3.4 Industry associations/non-governmental organisations (NGO)

Overall, 20 stakeholders that belong to the group of Industry associations/non-governmental organisations (NGO) have contributed to the survey. There were two organisations representing the civil sector, seven industry associations from the textile sector, two representing the automotive industry, four from the fire protection sector, one representing chemical manufacturers, one from the oil industry and one commercial testing laboratory.

3.3.4.1 Environmental and consumer NGO

A consumer umbrella NGO, representing a federation of 43 independent national consumer organisations from 31 European countries (EU, EEA and applicant countries), supported the activity initiated by the UBA to restrict more fluorinated substances. They highlighted the concern of more than 200 scientists from 38 different countries who signed the so-called Madrid Statement, which highlights the potential harm of PFAS. The statement concludes with a call for international cooperation on limiting the production and use of PFAS and for the development of safer non-fluorinated alternatives. Despite these concerns, most PFAS can be used in consumer products with little control, in the NGO´s view, including in cosmetics that are designed to be applied directly on the skin. At the same time, they find that wide-spread use of fluorinated substances in consumer goods often leads to expectations that many everyday products should exhibit enhanced stain resistance and oil/water repellence. For some products, such as high-altitude mountaineering clothing, these functions are seen indeed as essential, and may at present require the use of fluorinated substances. For many other consumer products such functions are either not essential or could be achieved by using non-fluorinated alternatives. Encouraged by the Greenpeace Detox campaign, several global textile manufacturers have for example pledged to end the use of PFAS, while many retailers, such as Danish Coop are eliminating fluorinated substances from their own brands. (see e.g. http://www.greenpeace.org/archive-international/Global/international/publications/detox/2017/PFC-Revolution-in-Outdoor-Sector.pdf or https://chemicalwatch.com/49963/danish-coop-to-phase-out-dirty-dozen) Although, the current uncertainties about possible adverse effects on the environment and consumer health, the NGO still evaluates the routine use of PFAS in everyday consumer products as highly problematic.

Due to their chemical properties, PFAS are extremely persistent: they are inert to most natural breakdown processes and persist in humans and the environment for decades. PFAS have moreover been detected in humans and wildlife all over the world. Breast milk for example has been found to contain PFAS and is thought to be the primary source of exposure of these compounds for most infants[52]. Against this background, use of PFAS should be strictly controlled and phased-out to the extent possible while support for the development of safer non-fluorinated alternatives needs to be increased. The evidence from NGO members’ comparative product tests tell a compelling story: across diverse product groups, fluorinated substances are present in some but not in all products. For example, in a 2017 test of food packaging, PFAS were found in some but not in all sampled products. More than half of the tested packaging materials

[52] see e.g. Haug et al. Characterization of human exposure pathways to perfluorinated compounds. https://www.ncbi.nlm.nih.gov/pubmed/21334069

were thus negative in the initial screening tests[53]. The evidence provided by that study demonstrates that alternatives do exist. Moreover, neither price nor brands appear to be a decisive factor: for example, comparable cosmetic products with and without PFAS are often available under the same brand name. For some applications, non-fluorinated alternatives may indeed currently not be available. In certain cases, such as e.g. implantable medical devices, time-bound exemptions could therefore be considered where a clear and justified need for continued use can be demonstrated. To encourage the development of safer alternatives, a strong market signal is however needed through an ambitious restriction of all PFAS, only allowing exempting essential uses that are clearly justified and time-limited to achieve the goal of reducing use of PFAS in consumer products.

They further argue that more than 3000 PFAS are, or have been, on the global market. Yet, most research and regulation continue to focus on a limited selection of rather well-known long-chain PFAS, particularly PFOS, PFOA and their precursors, with little information publicly available about the majority of PFAS. This situation, in their view, creates problems for regulators to prioritise substances for regulatory scrutiny, for companies to switch to safer non-fluorinated alternatives, and makes it all but impossible for individual consumers to avoid PFAS that may harm their health. An effective response to this situation demands that PFAS are targeted as a chemical group. Regrettably, in their view, is the tendency over the past years that industry replaced PFOS and PFOA with very similar substitutes. While they agree that some shorter-chain PFAS indeed seem to be less bioaccumulative, they argue they are still as environmentally persistent as long-chain substances or have persistent degradation products. Consequently, a switch to short-chain and other fluorinated alternatives may not reduce the amounts of PFAS in the environment. Further, because some of the shorter-chain PFAS are less effective, larger quantities may be needed to provide the same performance. As highlighted in a recent study commissioned by the EU chemicals agency, strict regulations are critical drivers for industry to substitute hazardous chemicals[54]. Rather than encourage manufacturers to move from one PFAS to the next, they claim that the envisaged restriction therefore needs to cover all short-chained PFAS. This would challenge manufacturers to innovate and develop more benign alternatives through materials innovation and green chemistry. More transparency about the uses of PFAS in consumer goods is also essential in particular for products which consumers come in direct, close or regular contact with, such as bed mattresses or textiles. As PFOA has come under increased scrutiny some products are now advertised as PFOA-free; this however does not mean PFAS-free, and such communication is potentially misleading consumers – and downstream users/retailers who in an NGO members' experience often does not seem to receive sufficient information from their suppliers. Greater transparency about PFAS used in consumer goods would in the NGOs view thus facilitate the identification and handling of exposure sources and enable suppliers, distributors and consumers to adopt a preventive approach and choose better alternatives. This would in turn reinforce incentives for industry to phase out the use of PFAS.

In their view a restriction could eliminate PFAS from the Circular Economy. The wide-spread use of PFAS in consumer products presents a pressing problem for EU chemicals policy, and not just on health and environmental grounds. The NGO states that addressing these extremely persistent substances takes on a new urgency as the EU's transition to a (more) circular economy begins to gain momentum. In a circular economy, it becomes even more difficult to control and limit exposures to chemicals of concern such as PFAS. Increased recycling and reuse

[53] see http://www.beuc.eu/press-media/news-events/harmful-substances-found-fast-food-packages-across-europe
[54] see https://echa.europa.eu/view-article/-/journal_content/title/reach-is-the-dominant-driver-for-substitution-more-action-is-needed

of products mean that it can take decades to eliminate legacy substances from material cycles and waste streams: for example, research suggests that even after a complete ban on the use of bisphenol A in paper receipts, it will remain in recycled paper for up to 30 years[55]. A true circular economy requires that toxic substances are absent as of their first use in consumer products. Better upstream management of PFAS and other substances of concern through greater reliance on grouping of chemicals and hazard-based standards is essential to detoxify the circular economy and to speed up the implementation of legislation meant to protect consumers. Continued used of PFAS is by contrast equivalent to the saying of kicking the can down the road and threatens to undermine consumer confidence in the circular economy[56]. Furthermore, given the size and diversity of the PFAS group and the current analytical difficulties in distinguishing among individual substances, the envisaged restriction could benefit from implementing methods based on total content of organic fluorine (TOF). In response to concerns about the adverse impacts of fluorinated substances, the Danish Veterinary and Food Administration has for example set a recommended TOF limit for paper and board food packaging. The limit was deliberately set to discourage the use of fluorinated compounds[57].

Another environmental NGO provided similar argumentations as presented above. Further to this they supplied the survey with information on similar activities on PFAS from the United States. This additional information is evaluated interesting in the context of definition and scope of an envisaged restriction: In March 2018, the US state of Washington decided on two bills for a ban of PFAS, in firefighting foams as well as in certain food packaging (to paper and plant fibers). Most interestingly and worth noting is that the applied definition is the existence of carbon-fluorine bonds: "Perfluoroalkyl and polyfluoroalkyl substances" or "PFAS 4 chemicals" means, for the purposes of firefighting agents and firefighting equipment, a class of fluorinated organic chemicals containing at least one fully fluorinated carbon atom[58]. So far, 16 bills to regulate PFAS have been introduced in nine states, and US EPA planned to hold a summit in May 2018[59]. This follows public outrage in many communities that have been impacted by PFAS water contamination from PFOA replacements (https://cen.acs.org/articles/96/i10/Chemours-told-to-cut-fluorocarbon-air-pollution-from-North-Carolina-plant.html).

Furthermore, the NGO shares the view that the stricter regulation of PFAS is part of a prerequisite to establish a clean circular economy. In their view, the circular economy will only be a success, if material cycles can be trusted to result in high-quality recycling products[60].

3.3.4.2 Substance manufacturer associations

An association from the fluorine compound manufacturers provided a list of fluorochemicals and highlighted the benefits of their continued use. They do not support an envisaged restriction of short-chain PFAS. They claim C6 fluorotelomers are at present the primary alternatives to C8 fluorotelomers. The following table describes the main applications as well as benefits of C6

[55] see https://www.eea.europa.eu/publications/circular-by-design/
[56] See also http://www.beuc.eu/publications/beuc-x-2017-084_how_to_detoxify_the_circular_economy.pdf
[57] For details, see: https://www.foedevarestyrelsen.dk/english/SiteCollectionDocuments/Kemi%20og%20foedevarekvalitet/UK-Fact-sheet-fluorinated-substances.pdf
[58] http://lawfilesext.leg.wa.gov/biennium/2017-18/Pdf/Bills/Senate%20Bills/6413.pdf and http://lawfilesext.leg.wa.gov/biennium/2017-18/Pdf/Bills/Session%20Laws/House/2658-S.SL.pdf#page=1
[59] https://www.epa.gov/newsreleases/epa-convene-national-leadership-summit-take-action-pfas
[60] See NGO briefing for details: http://www.chemtrust.org/wp-content/uploads/chemtrust-circulareconomy-aug2015.pdf

fluorinated polymers and fluorinated surfactants (see Table 20). Non-fluorinated alternatives in their view may be used in applications requiring limited performance (water-repellency and water-based stains only, fire fighter training and extinguishing of some Class B fires), but not in high reliability, durable, safety applications, where often a combination of the unique properties (oil repellency and oil-based stain prevention; film-formation) of fluorotelomers is required. For sectors requiring such combinations, the absence of C6 products would imply less performing, less safe products, and with a higher carbon footprint throughout their life cycle. The substitution from C8- to C6-based products was the result of years of research, customer requalifications and significant investments. Substitution is part of innovation and as such is a permanent effort of the association members, which are also developing non-fluorinated alternatives. Nonetheless, as stated above, substitution to non-fluorinated substances is currently possible only for some specific performance applications. Furthermore, C6 fluorotelomers are key in supporting the transition from C8 fluorotelomers globally. A restriction on C6 fluorotelomers, and short-chain fluorinated substances more generally, would slow down that transition process in Europe. It would also discourage any efforts in this direction in emerging economies in the view of the association.

Table 20: Main applications, as well as benefits, of C6 fluorinated polymers and fluorinated surfactants

Industry	Application	Property	Benefit	Fluoro-Technology
Performance textiles and carpeting	Interior textiles of cars/aircrafts	Water, Oil, Stain, Soil Protection	Improved cleanability, longer fabric life lowering overall maintenance costs	Fluorinated polymer
	Outdoor apparel and equipment	Water, Oil, Stain, Soil Protection	Durable, lifesaving protection in severe environments, longer useful garment life	Fluorinated polymer
	Professional protective textile	Durable, high water and oil (solvent) repellency. Chemical resistance	Life protection in severe environments, protection against hazardous chemicals, protection against water and liquids in a (fuel) fire.	Fluorinated polymer
	Non-woven (Medical)	IPA repellency (isopropanol alcohol); repellency to blood, urine and other body fluids	Prevention for medical work wear for the operating theatre; protection of hospital staff; departmental, ward and surgical clothing for nurses, nursing staff and doctors	Fluorinated polymer
	Non-woven (automotive)	Water- and oil repellency; Resistance to liquid chemicals (Battery), Diesel- and Gasoline; Heat resistance	Protection of components in the motor area; insulation	Fluorinated polymer

Industry	Application	Property	Benefit	Fluoro-Technology
	Carpets/home textile	Water, oil, stain, soil protection, reduced dirt pickup	Easy clean, longer useful life	Fluorinated polymer
Food packaging		Oil and grease resistance	Enabling paper packaging for pet food, microwave popcorn, quick service restaurant, meals; reduces potential for burns from hot oil migration through the packaging or wrap; maintains aesthetics and integrity of packaging material	Fluorinated polymer
Electronics	Semi-conductors (etching and resist materials, cleaning fluids)	Wetting and levelling to control and improved chemical etching. High purity, pure drying cleaners	Ability to manufacture semi-conductors	Fluorinated surfactant
Firefighting foams	Airports, oil fields, fuel storage, military applications	High efficiency oxygen starvation, faster extinguishment times, better burnback resistance	Quicker extinguishing of fires, resulting in saved lives, reduced asset losses; fire-fighter safety	Fluorinated surfactant
Building and construction	Paints, building materials protection	Wetting, levelling, mold-releasing, anti-fouling	Longer useful lifetime, lower repainting interval, reduced paint waste from recoat preparation	Fluorinated surfactant

They further argue, C6 fluorotelomers have been developed with the objective to produce alternatives to C8 that could meet equivalent performance levels while not presenting significant risks to the environment or human health. As a consequence, C6 alternatives, as well as their potential degradation products, in particular PFHxA, have been well studied. On ecotoxicity, the RMOA on PFHxA and PFHxA related substances, issued by Germany (BAuA), states that "*standard data for ecotoxicity of PFHxA does not give reason for concern*" (p. 5). On toxicity, the review of all data available in vitro and in vivo analysed up to date does not suggest that PFHxA is a CMR nor an endocrine disruptor. In addition, PFHxA does not bioaccumulate. These data have been compiled in a review paper to be submitted in a peer-reviewing journal. In 2017, the French Agency ANSES derived a chronic TRV by ingestion at 0,32 mg/kg/d. It is very unlikely that any individual would be exposed to such levels.

C6 fluorotelomers are intended for use in applications requiring well defined performance levels, in relevant applications for the customers and the society at large, for which substitutes are not expected to be available in the near future, despite significant efforts in research. The association members claim to apply state-of-the art technology in their production processes to control emissions and are engaged in a dialogue with their downstream users to inform on best practices for the same purpose. As part of its commitment to reducing the environmental footprint in the value chain, the association has developed best practice guidelines for the textile and fire-fighting foams sectors. In the RMOA on PFHxA, it is stated that the concern with PFHxA relates to drinking water. They state the EU legislation on drinking water is currently under review. As part of this review, concentration limits for certain PFAS, some of which fall within the scope of the survey, have been proposed and are being discussed. The European Commission applies the principle of Better Regulation which aims for targeted regulation that goes no further than required, in order to achieve the necessary objectives and bring benefits at minimum cost. In line with this principle, in the view of the association, it is questionable whether a REACH restriction would constitute the most suitable and proportionate regulatory instrument. Last but not least they repeat their statement that C6 fluorotelomers are key in supporting the transition from long-chain fluorinated substances. In Europe, restricting C6 will considerably slow-down the transition process in applications that have received long-time exemptions. Outside of the EU, the US and Japan, C8 fluorotelomers, as well as PFOA, continue to be predominantly used and the political support and timeline for a global phase out remains uncertain.

The association members are also producers of non-fluorinated alternatives and despite years of research and significant investments, comparable performance could only be reached by non-fluorinated alternatives for water repellency only. This is due to the unique properties of fluorinated compounds such as lowering surface tension. Where possible, substitution has taken place, and efforts are ongoing amongst the association members and beyond to find new alternatives.

3.3.4.3 Textile industry associations

The importance of PFASs for certain specialised textile applications, such as personal protective equipment (PPE) and technical textiles, was highlighted for associations in the textile sector. They referred to the information already collected in the frame of the PFOA restriction and requested a, at least timely limited, derogation for such applications, since the short-chain PFAS under discussion do serve as substitutes to PFOA and PFOA related substances. They stated that some time is needed to avoid another regrettable substitution, because currently available alternatives do not fulfil all the requirements for these special textile applications.

In particular they provided following concerns:

- *„Importance of fluorinated substances in EU textile and apparel industry*
  The European textile and apparel industry does not only represent home textiles and clothing, but also specialised technical textiles and PPE. The European textile and apparel companies are fully supportive of more sustainable products and replacement of harmful chemicals when possible. It is important to highlight that certain applications such as technical textiles and PPE need performance chemistry to comply to safety standards and provide a certain function such as oil, water, and chemical repellence.
  In case of a restriction of all C6-C4 chemistry, the EU textile industry would experience serious challenges in meeting safety standard requirement with alternatives that are not suitable for certain applications. That might imply a possible modification in the standards for protective clothing—unless an exception will be granted. It should be highlighted that a change in the safety standards might imply lower levels of protection.

- *Short-chain PFAS as a last available alternative*
  Nowadays, companies treat their textile materials with C6, the currently available and allowed alternative, in order to meet the requirements of different standards for PPE. Research has shown that even short-chain fluorinated substances have certain limitation as opposed to C8 chemistry for certain applications:

  - *Oftentimes protective textiles finished with C-6 chemistry need to be re-impregnated after each washing to meet the criteria required for testing. Repeated impregnation of C-6 also implies more usage of binders which has a negative effect on flame retardancy. This might cause issues to apply heat-sealable retro-reflective strips and logo's on textiles that require frequent washing.*
  - *A study performed at the request of a project group CEN/TC162[61] WG2, shows clearly that textiles that are treated with C-4 chemistry do NOT meet some of the minimum requirements that are requested by standards for protective clothing.*
  - *According to the ECO-DWOR project by Centexbel and Flik, fluorine-free alternatives perform well with water repellence but not for oil and solvent repulsion. Some of these products for example silicon based impose limitations on labelling of textiles. Short-chain fluorochemicals provide for oil and solvent repellence, but are less performant (less effective) than C-8 due to the lower number of carbon atoms. In that regard, C-4 chemistry offers a limited oil repellence and even in cases when C-4 provides a better oil repellence, water repellence is limited. C-6 chemistry offers good water and oil repellence but in specialised applications such as PPE requiring flame retardancy, there are limitations to achieving multifunctionality which also depends on the type of fabric. Possible residues (e.g. spin finish) remaining on the textile showed to decrease the performance of fluorine-free alternatives and short-chain chemistry, which was less of a problem in C-8.*
  - *Preliminary results of the Life+ project MIDWOR[62] researching alternatives to long-chain fluorocarbons used in textile industry show that silicone-based alternatives are not effective in oil repellence in certain applications particularly technical textiles due to its surface energy being higher than the surface energy of oil. EURATEX supports the work of this project as an Advisory Board Member and co-organizer of a workshop with researchers and textile and chemical companies to discuss "real life" application of tested alternatives and their limitations*."

Other associations commented following a similar argumentation. It was also mentioned several times that there are no direct uses of the short-chain PFAS themselves. Potential sources are always fluorinated Polymers (referred to as fluorotelomers or fluoropolyacrylates).

3.3.4.4 Fire protection industry associations (& oil industry)

The Fire protection associations raised concerns on a phase out of short-chain PFAS on the EU market, as they also see some applications where no full substitution can be achieved, currently.

[61] CEN/TC 162 - Protective clothing including hand and arm protection and lifejackets https://standards.cen.eu/dyn/www/f?p=204:7:0::::FSP_ORG_ID:6143&cs=1172B5BBB1F1411294D97D98575DE977D

[62] https://www.midwor-life.eu/

One stated: "*Fluorocompounds that are used in firefighting foams which are particularly dedicated to be used on (large) fires of liquid fuels and chemicals. The Fluorosurfactants/-polymers provide Oleophobicity which drastically reduces fuel pick up (emulsion of non-water miscible liquids into water by surfactant action). This again reduces foam destruction by emulsifying fuel into the foam blanket, reduces re-ignition of picked up fuel leading to a destruction of the foam blanket and mitigates vapour penetrating the foam blanket.*

The aqueous film which can be formed with AFFF (aqueous film forming foams) does also help to close out fires in the shadow of obstacles relative to spray direction of foam as well as reduce vapour release. This secures the fire scene helping firemen to control liquid fires in complex areas such as industrial sites or tank farms.

These effects allow for applying AFFF and the likes as liquids (e.g. by big water guns) since these foam agents do not require a special foam quality to be successful and effective. Application as a liquid with very little foam expansion again allows for large distance application hence fighting large tank fires from safe distances. It also allows for sprinkler application which is not possible with fluorine-free foams unless special foam making sprinkler nozzles are installed."

Similar information was provided by a second association from this area. These state:

"*The main uses of fluorinated substances in firefighting foams are as fluorosurfactants and fluorochemical foam stabilizers. Class B foams that contain fluorosurfactants are the most effective foams currently available to fight high-hazard flammable liquid fires in military, industrial, and aviation applications. Their unique film-forming and fuel repellency properties provide rapid extinguishment, burnback resistance and protection against vapor release, which help to prevent re-ignition and protect fire fighters working as part of rescue and recovery operations. When fluorosurfactants are combined with hydrocarbon surfactants and mixed with water, the resulting solution achieves the optimum surface and interfacial tension characteristics needed to produce an aqueous film that spreads across the surface of a hydrocarbon fuel. It is this film formation feature that helps provide superior fire performance and is the source of the designation – aqueous film-forming foam (AFFF). The association has attached an overview of the mechanics of film formation that provides additional information on the important properties that fluorosurfactants provide to firefighting foams.*

C6 fluorotelomer-based products include C6-monomers, C6-intermediates, C6-surfactants and C6-side-chainfluorinated polymers. Based on published literature, key environmental breakdown products would include 6:2 fluorotelomer sulfonate (6:2 FtS) and perfluorohexanoic acid (PFHxA)."

A similar statement was also provided by an Australian association from the firefighting sector and a German association from the mineral oil sector that might be effected by fires that are referred to above. The Australian association furthermore stated that shorter chain PFAS should not be regulated in the same way as PFOA because of the less toxic properties of the C6 PFAS.

Currently the association claims that there is a continued need to use short-chain PFAS in class B firefighting foams to protect lives and high-value property against flammable liquid fires in applications that are critical to society such as aviation, oil and gas production, and military. Although fluorine-free foams can provide a viable alternative to fluorinated foams in some applications, they are not currently able to provide the same level of fire suppression capability, efficiency, flexibility, and scope of usage. Fire test results presented at international fire protection conferences in 2011, 2013, 2015 and 2016 all show that fluorinated foams are significantly more effective at extinguishing flammable liquid fires than fluorine-free foams.

Based on existing data, in their view the short-chain PFAS used in firefighting foams are generally considered to be low in toxicity and not bioaccumulative according to current regulatory criteria. This leads the submitter of the information to the conclusion that short-chain PFAS are not a high risk for the environment. It is understood that these chemicals are persistent in the environment and thus their use does come with some risk. The association promotes the use of best management practices as a way to minimize discharges to the environment and reduce the risk from the use of class B foams. Short-chain PFAS should in their view not be restricted from important professional applications where alternatives are not available. They state that the existing data on the environmental impact of short-chain PFAS does not justify such severe restrictions. This is especially true for their use in firefighting foams, which have a high relevance to society. If restrictions are placed on short-chain PFAS, they claim that firefighting foam is an application that should be exempted from those restrictions. Based on own assessments the stakeholder concluded concerns with regard to the environment are not justified.

The main obstacle to the substitution seen in firefighting foams is performance. Although the performance of fluorine-free foams has improved significantly over the last decade, they are not currently able to provide the same level of fire suppression capability, efficiency, flexibility, and scope of usage as fluorinated foams. Fluorine-free foams are inherently oleophilic (fuel attractive). In the absence of oleophobic (fuel-repelling) fluorosurfactants, fluorine-free foam can easily pick up fuel and the contaminated foam degrades quickly and becomes flammable. This fuel contamination problem compromises the fire performance and limits the application of fluorine-free foams. In addition to performance, there are issues for fluorine-free foams related to compatibility and viscosity. Whereas most AFFF agents are compatible and different brands can be mixed in the same equipment, fluorine-free foams are generally not compatible and cannot be mixed with other types of foam agents. This can cause issues for fixed fire protection systems and military applications. Fluorine-free foams are also more viscous than AFFF agents, which can cause problems for proportioning equipment.

3.3.4.5 Semiconductor associations

The semiconductor manufacturing industry has in the past decade been moving away from the use of long-chain perfluorinated materials. The semiconductor industry has eliminated using PFOS in its manufacturing process. This complete elimination is described as a major environmental management achievement for the European semiconductor manufacturing industry sector. This effort was the result of over fifteen years of proactive work by all companies in identifying appropriate substitutes and making significant investments in development, manufacturing process qualification and process modifications. The industry is also moving away from PFOA and related substances where feasible. These substances have been used in specialty formulations for their critical properties in semiconductor manufacturing (in the photolithography process manufacturing step). This includes for example use in photoresists and in antireflective coatings for photolithography which is the critical step of patterning in semiconductor manufacturing. The replacement for these elements was the short-chain chemistry. The industry would underline that these specialty materials and mixtures used in semiconductor manufacturing processes play a crucial contributing role in the sector`s innovation. The European semiconductor industry has a long history of responsible use of perfluorinated substances and has made significant efforts and progress to transition to perfluorinated substances of lower chain lengths (short-chain PFCA, PFSA alternatives). The transition of the semiconductor industry towards the shorter chain homologues for critical manufacturing uses has taken many years to realise. Photolithography materials in semiconductor manufacturing process are now dependent upon the use of shorter chain perfluorinated chemistries. These shorter chains are present as a critical and technology essential constituent of the formulation. There are no general non-fluorinated substance alternatives that can adequately provide the functional properties for the critical high-tech applications required within the semiconductor manufacturing process. Any development in this area would require first novel chemistries to be invented.

Short-chain PFAS are used in low concentrations in specialty formulations for their critical properties in the photolithography processes in semiconductor manufacturing. As these are specialty formulations, they remain critical for process use though the actual use volume is not in a high tonnage volume band. Photolithography is the process which generates the patterns on the wafer which form the circuit after processing in other modules. The procedure covers the most critical process steps of the semiconductor manufacturing process flow. The steps are repeated several times (in the range between 20 and 60, according to technology) with the manufacturing process to build up the layers of features of the transistors and interconnects that finally becomes an array of microchips on the silicon wafer. Photoresist: A photoresist is a light-sensitive material used to transform a pattern from a photo mask to the wafer. The photoresist coat process takes place in a specific tool, called “track”. First a primer is applied to the wafer to increase the adhesion of photoresist. Then during coat, photoresist is dispensed onto the wafer. The wafer is spun at high speed so that the photoresist spreads extremely evenly across the wafer surface. Each resist is a custom designed blend designed for the particular layer, wavelength, substrate reflectivity and thickness required. Finally, during baking the resist is dried by removing the solvent to produce a mechanically stable film. The biggest challenges are coverage over uneven surfaces, thickness, pattern defects and particle contamination. Short-chain fluorinated substances are used here as a surfactant to improve coverage and exceedingly precise uniformity and also to change the absorption and refractive index. During exposure the wafer is exposed chip by chip using a product and layer specific photomask. Anti-Reflective Coating (ARC): Antireflective Coatings are used to reduce the reflectivity of the photoresist coating. For example, ARC layers are spun onto the wafer prior to resist coating. They are used to reduce the reflectivity variation of a substrate much like “anti-reflective” glass. This stops “notching” in the pattern caused by reflection from underlying layers. Short-chain fluorinated substances are used to improve film forming properties and adjust refractive index (RI).

In the semiconductor industry there is the view that the risk for the environment is determined by volume and openness to the environment. Since this is very well controlled in this sector no risk (or very low) risk is provided to the environment from this sector-use. In the opinion of the semiconductor associations PFAS should be restricted in all professional applications. As per ECHA’s REACH Guidance the widespread use by workers in a ‘professional’ use context scenario should not be confused or equated to ‘industrial’ use at a site. Industrial uses that are process critical and where emissions are avoided and controlled should be allowed, while professional use with no control to the environment should be restricted. Fluorinated substances are essential to the semiconductor industry’s manufacturing processes due to their unique substance characteristics. The potential risk to the environment and human health is managed in semiconductor manufacturing through stringent risk management measures implemented in the manufacturing factories. Responsible use in this case includes avoidance and control of emissions into the environment. Semiconductor manufacturing in Europe depend upon the availability of short-chain fluorinated substances for use in photoresists and antireflective coating in photolithography. For an envisaged restriction, semiconductor uses would need to be exempted. The overall impacts of non-availability would be significant, leading to semiconductor production leakage to factories outside the EU that without such legislative measures would not take place. They further claim that for an envisaged restriction, semiconductor photolithography uses would need to be exempted. Semiconductor manufacturing in Europe depends upon the availability of short-chain fluorinated substances for use in photoresists and antireflective coating in photolithography. The impacts of non-availability would be significant, leading to semiconductor production leakage to factories outside the EU that without such legislative measures would not take place.

3.3.4.6 Imaging associations

In another field the PFAS are used in is the production of photographic material or x-ray material, where the substances (or precursor substances) can be contained as wetting agents in very small concentrations.

Here some PFAS are essential for the application of coating layers during the manufacture of some remaining conventional photographic products, i.e. products in which the image formation is based on silver halide technology. They have multiple functions, serving

- as surfactants,
- as static control agents (tribo-electric properties of the coating),
- as dirt repellents during coating operations,
- as friction control agents.

These PFAS substances are unique in that they provide the combination of all these properties in one molecule, without any adverse effects on photographic performance. The PFAS substances are the active components of commercial surfactant mixtures; small amounts of these mixtures are included in the photographic coatings. In addition to controlling the surface tension and thus the wetting properties of the coatings, they have significant antistatic effects. These substances not only provide performance features necessary for the manufacture and use of conventional photographic products, they also provide important safety features by controlling the build-up and discharge of static electricity and are needed to prevent damage to the sensitized photographic layers and thus prevent product damage or even waste. In order for alternatives to these PFAS substances to meet the technical specifications for use in products, they must provide the equivalent combination of surface-active properties that, to date, have not found with any other single class of chemicals.

These PFAS substances:

- Lack photoactivity and thus do not interfere with the imaging process
- Promote uniformity of photoprocessing results by controlling surface wetting properties
- Control splicing tape adhesion properties
- Improve camera, projector, and printer transport to eliminate unwanted photographic effects, and
- Prevent the build-up of particles that can clog magnetic strip readers. Coating aids must not be photoactive. Otherwise, unacceptable fogging or speed effects may occur in the coatings.

The ability to control surface tension in imaging materials is a critical aspect of the use of these PFAS substances as coating aids. These PFAS substances play a key role in minimizing manufacturing waste by contributing to the technology for creating coatings of high complexity in a highly consistent manner. The coating aid must allow the rapid uniform spreading of the layers so that irregularities in the coatings are avoided. Any irregularity in coating thickness makes imaging materials useless and increases manufacturing waste significantly.

Perfluorinated coating aids also have special properties at low concentrations for controlling static charge during the manufacture and use of imaging materials. This is particularly important for imaging materials that have a high sensitivity to light, including light produced by static discharge during transport of imaging materials. Excessive friction during the transport of imaging materials and contamination of imaging materials by dirt or clogging of magnetic strip readers with debris can lead to significant waste of imaging materials during manufacturing and use.

Applications where short-chain PFAS are used are typically photographic materials where formerly either PFOS or PFOA had been used and where in the process of looking for alternatives a PFAS substance proved to be the only alternative acceptable in terms of the required properties of the photographic material. As extensive research has already been done to find non-(per)fluorinated alternatives as the preferred alternatives for PFOS or PFOA related substances, there will be some critical photographic materials where such alternatives have not been found and for which a derogation will still be needed should restrictions be imposed also for short-chain PFAS. PFOS / PFOA and some PFAS substances are “unique” in that they combine a number of properties required in state of the art photographic coatings into one molecule (see above). Sustained research to find alternatives resulted in some applications in finding combinations of two or more hydrocarbon substances demonstrating a super-additive effect that resulted in performance characteristics comparable to PFOS / PFOA or specific PFAS. However for some specific applications suitable alternatives have not been found, despite intensive research. Substances to be used in photographic coatings require properties inherent to the manufacture of imaging materials, e.g. lack photoactivity and thus do not interfere with the imaging process, do not interfere with a number of other intrinsic properties of conventional photographic coating solutions such as colloidal stability. As a consequence, some known possible alternatives for PFOS and PFOA that have been identified in other areas – such as silicone products and siloxane compounds – are hence in practice not usable as alternatives in the manufacture of conventional photographic products.

3.3.4.7 Automotive

The main applications and uses of Fluoro Technology in automotive industry are fluoropolymers (seals, fuel line tubing and parts, o-rings, hoses, wires, cables etc.) and fluorotelomers (treatment of fabrics, seat belts, leather, carpet, non-woven in fuel cells or batteries, insulating material etc.). The surface coating of car parts which is important for the automotive industry would be also affected. Only fluorinated substances are able to resist the destruction in a high oxidative medium (e.g. Chromium plating). Also affected would be the plant fire brigades which are using firefighting foams containing fluorinated substances.

Many vehicle components need oil-, water- or dirt-repellent surfaces and/or a high hydrolysis or acid resistance. These properties can often be achieved only by fluorocarbon containing coatings. For production of appropriate articles the use of C4-C7 PFAS in the supply chain is indispensable. The long-chain C8-chemicals which were formerly used for coating, have been replaced in the last years by C6-chemicals like Perfluorohexanoic acid (PFHxA). These are most likely suitable to fulfil in most cases – but not in all – the previous product characteristics. Even C4-chemicals could not fulfil in many cases the required product properties. Fluorofree alternatives are offering significant deficits, so that they cannot be used as appropriate substitutes.

3.3.5 Conclusions

The data collection on the short-chain PFAS showed that these substances are present in a wide range of applications, in most cases as basic raw materials (building blocks) in the production of fluorinated polymers. Direct uses have been the exemption. Only some uses of the substances in fluoropolymer manufacture, in semiconductor and photographic industry and the firefighting foam sector are direct uses of short-chain PFAS. All other uses rely on the telomeres that might contain residual short-chain PFAS or could degrade to them over time.

In many sectors stakeholders stated that the substitution potential is limited, when special properties must be met. These are:

- Oil grease or dirt repellency
- Special durability of treated materials or in a specific process under harsh conditions

Examples were working protection apparel (e.g. in hospitals), the AFFF firefighting foams and engine isolation membranes in cars.

Regarding the possibility to substitute the PFAS the situation of the industry stakeholders differed. While some generated only a small share with products linked to the PFAS, others generated > 90 % with such chemistry. In the first case, a restriction might have a less significant impact on the company in total even though the consequences for this department in the company can be severe and cost a relevant amount of jobs if the restriction results in the termination of operations in this field. For the companies that rely on the fluorochemicals to a larger extend, a broad restriction in the field of short-chain PFAS might threaten the existence of the entire company. As the transition towards C6 PFAS was already a way to implement the restriction on PFOA (and earlier restriction on PFOS), this seems not possible in some areas, currently due to a lack of technical feasible alternatives. The same can be stated for the use of alternatives. Some companies already have alternative products in their portfolio and a restriction might just lead to a transition to these. Hence, a decrease of turnover from fluorinated products towards an increase of the alternatives. Other companies currently do not have alternatives and would therefore just suffer from losses. This is also expressed in the duration by when alternatives could be introduced to the market, while some companies can imagine an introduction in about five years, others claim to need at least ten years even to only develop such an alternative (development of new chemistry) followed by a market introduction phase.

On the other hand many stakeholders shared the view that PFAS are a problematic chemistry, regarding environmental hazards and assumed human health effects, so they potentially should not be used in everyday applications. Some NGOs highlighted that risks that follow the use of the substances and the need to protect especially vulnerable groups, originate not only from direct exposure form everyday products, like food packaging or textiles, but also increasing concentrations of the substance in the environment, e.g. the drinking water.

4 IT based surveys in the frame of restriction activities under REACH

Besides the bare data collection, the project scope was to investigate how IT-based surveys can be optimised for future information collection. It was the aim to generate a standard questionnaire that can be used in the frame of such activities (see Appendix C, p. 130 (English) or D, p. 151 (German))

Restriction processes depend on a large extend on information from industry stakeholders. Such information is:

- Production or import volumes of substances and mixtures that contain substances under concern
- Use conditions of substances or mixtures, especially those that might lead to emissions – also a quantification of the emission and the applied risk management is important to know
- The content of substances under concern in products (substances – here in this particular project e.g. content of free C4/6 compounds as impurities in side chain fluorinated polymers, mixtures and articles)
- Availability of alternative substances or technologies
- Timelines for substitution/adaptation of processes and cost for such substitution

In the author's experience, this target group often has a low motivation to collaborate actively in such data gathering processes. Some obstructions might be caused by an additional workload to collect the information (because data is usually not aggregated in one department of a company). Another challenge for stakeholders might be found in approving the integrity of data-handling when confidential data is addressed. Data holders are reluctant to share many kinds of information that are necessary to elaborate a meaningful dossier. Reasons are business confidentiality towards competitors but also practical issues like data submission (online not always approved). Furthermore, it can be observed that the number of public consultations with regard to chemicals has increased over the last years due to several REACH processes that are based on stakeholder information exchange like, e.g. SVHC identification, applications for authorisation and later in restriction process when the official draft is discussed. This extend of consultation makes it difficult to be involved in all relevant processes with the necessary intensity to prepare descriptions of technical processes that meet the expectations of the committees later in the process when the proposal is evaluated. This leads to a high level of uncertainty regarding appropriateness of proposals/exemptions and representativeness. Last but not least is the outcome of the information collection a restriction proposal that most likely will impact the current use of the substance under consideration and as a consequence will result in the need to change current practice in the companies. Therefore, such "unofficial" data gathering processes that are not part of the processes which are defined in the REACH text should be as user friendly as possible.

From an authority perspective there is a high interest in receiving the information in the most comfortable way. Since the restriction proposal usually covers the complete market of a substance or at least all companies in a specific segment of the market, a company focussed perspective is not suited for all questions to be addressed in a restriction dossier. Information therefore have to be processed to a certain degree, to derive more general findings. Most obvious examples are data about tonnages that are placed on the market and its distribution in the different products and uses. For this reason an IT-based surveys should provide information in a standardised way, so they can be easily processed later on.

Another aspect of standardisation is that users of IT-based surveys can to some extent get guidance for what type of answers are expected. That makes it easier for the user to find the right type of information (even though it is understood that some information is not readily at hand in the way it is requested and might therefore cause some effort in the organisation).

Experiences of the authors from this and other information gathering activities in the REACH implementation and other regulatory processes showed that the selected methods must have the following features:

- Easy access for a large group of stakeholders: The favourable way (from a data collector's perspective) is to approach stakeholders via specific contact points (persons). This would avoid to send data requests to a person in an organisation which is not aware of the context of the data collection and might therefore ignore such a request.
  To a certain degree, this can be realised by preparatory research (literature, internet). On the other hand, especially contacts and application areas of interest are often not known in advance (this is one key challenge when a restriction proposal has to be prepared). Therefore, the survey should have an easy access. Furthermore, complicated registration operations lower the motivation to participate. It should also be possible that various persons from one organisation have access to the questionnaire and can answer questions specific to their knowledge.
- Applying stakeholder-specific language: When stakeholders are addressed, it is important that the proposed questions are well-understandable. The REACH-terminology may not always be the best choice, especially when non-regulatory persons are the ones that provide the input. This will most likely be the case if specific operational conditions on uses, research on alternatives or socio-economic effects for the organisation will be questioned.
- A certain degree of guidance and formalisation to avoid the need to elaborate long free texts (which would cause additional organisational efforts to the stakeholders and to the authorities who have to extract the necessary information).
- Enough flexibility to allow the stakeholder to describe his special situation: Often stakeholders do want to add very specific reasoning for technical or socio-economic facts. Such information can hardly be retrieved by standard questions and will always require some free text options, either by direct input sections or the possibility for uploads. The latter is also important if it is the intention of a stakeholder to submit large data sets. Automated export from the stakeholders existing database systems could simplify the data submission on the input side. On the other hand it should be well-considered that all non-standardised input sections will increase the workload on the data evaluation side.

The last two points are contrasting each other to a certain degree. Therefore, these features have to be considered carefully when the questions were drafted.

In the first survey on the C9-C20 PFCA, only one questionnaire was set up that reflected the various roles under REACH in the supply chain (or as a stakeholder)

These were:

- Substance manufacturers/importer
- Formulators of mixtures that contain fluorinated compounds
- End users of substances or mixtures that contain fluorinated compounds (distinguished between process chemicals and incorporation in articles)
- Manufacturer/importer of fluorine-free alternative substances
- Formulators that produce fluorine-free alternative products (mixtures)
- Third parties (NGO, Associations etc.)

The roles were selected by the participants, themselves. For each role a selected set of questions had to be answered. Thus, a company that only selected the manufacturer role did not get questions that were specific for the end users (e.g. on details on the process emission). This approach was very laborious regarding the tool programming and it was anticipated that this would even be increased if the scope of the substances covered in the second survey would be higher. Therefore, the decision was taken to design five different questionnaires for the different roles in the second part of the project, whereby the roles that were providing information on fluorinated substances and the ones that provided information on alternatives were covered by one questionnaire. This simplified the process of programming the survey(s) significantly and it was easier to establish them with the usual customized features of the IT-tool.

4.1 Technical and organisational aspects of the survey process

As part of the tendering procedure the consultants proposed to facilitate a questionnaire with an IT-tool called "lime survey"[63]. This tool is an open source application and can be used free of charge. The open source architecture allows far reaching adaptations of the tool. This allows UBA to develop own functionalities, standard formats etc. which was a core selection criterion.

It is also possible to use hosted versions of the tool online. When such platforms are used, the adaptations are limited. Still own layouts can be programmed and uploaded. Such a hosted version was used in the frame of this project.[64] An overview of the software functionalities is given in Table 21.

Table 21: LimeSurvey overview software features

Functions	Features of LimeSurvey
Registration	Tool can be used with or without registration (Anonymous/non-anonymous participating); Registration allows individualisation of a survey, each participant gets an individual link to access the survey/ data entry can be interrupted several times; Sharing the link allows to access the survey by other persons, the participant has full control of the data until he finalises the data entry and submits the data via a finalisation button

63 https://www.limesurvey.org/de/

64 https://oekopol.limequery.com/index.php/admin/authentication/sa/login

Functions	Features of LimeSurvey
Structural components and navigation options:	Various views can be implemented, e.g.: One question only per browser window is shown (⇒ no scrolling needed, step by step entry); A set of questions is shown per browser window (⇒ limited scrolling needed, participant gets an overview on part of survey, e.g. content wise related questions and an easier understanding of the context); Questions all in one browser window (⇒ very much scrolling when longer questionnaires are used but complete overview on questions without further navigation); Additional navigation possible via navigation tree on side bar possible (navigation to question groups possible)
Design features	Implementation own corporate designs and colour schemes possible
Language settings	Survey is designed in one language first and allows then translation in tile windows into other versions. All question logics etc. are only done in the original language; no automatic translation options within tool
Printing/preview options	Direct printing functions available (although limited quality, lack of good layout); Preview of survey not possible, previews have been produced in PDF format separately and provided on the welcome webpage in the Ökopol web presence
Automatic invitation and reminder functions	In Surveys with registration: reminders can be sent manually; reminder can be programmed to be sent automatically to avoid doubled requests
Guarantee of data security	Data is encoded with SSL-codification; Server host located in Germany – guarantees "European Data Protection Law"; Survey participants have always fully extended access to their data and are able to delete their data whenever they want as long as survey is not finalised

4.1.1 Survey Website

In the initial planning of the project it was agreed that invitations to the survey should be possibly sent from the tool (which is possible in case sufficient information is available – at minimum an e-mail address). Furthermore, a registration of yet unknown potential market actors needed to be established (this is especially important for actors that provide alternatives as these are not known in detail).

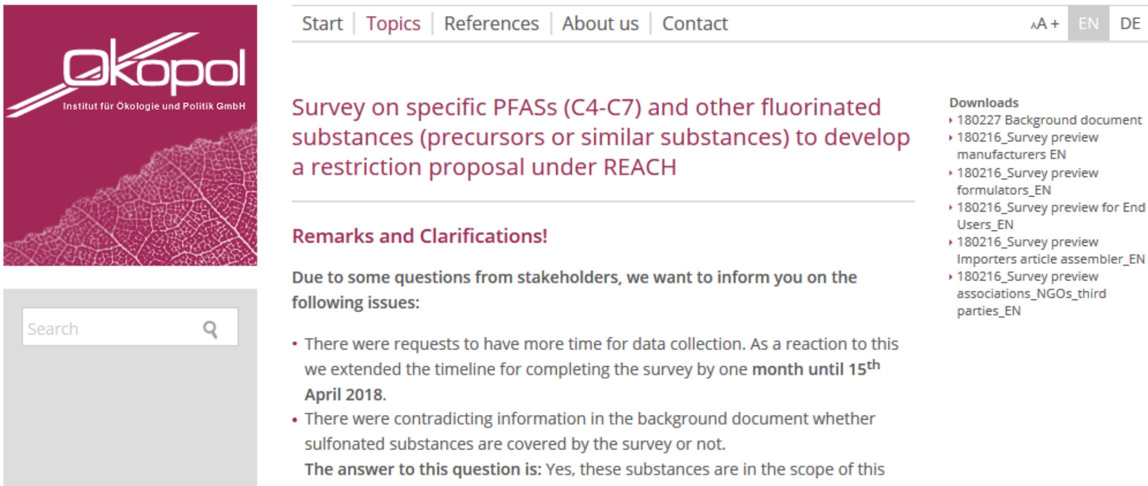
To facilitate this registration, we did not implement a starting page in the tool itself which would have been possible in principle but would have caused some extra efforts of programming. We instead made use of the Ökopol website as a starting portal. It had the advantage that there was full access and a setup of pages was easy to facilitate. From the Ökopol website it was possible to access the registration site of the tool, which was on the server of the service provider. The Ökopol survey portal was accessible under

- http://www.oekopol.de/en/themen/chemikalienpolitik/umfragen/pfca/ (English Version) and

- http://www.oekopol.de/themen/chemikalienpolitik/umfragen/pfca/ (German Version).

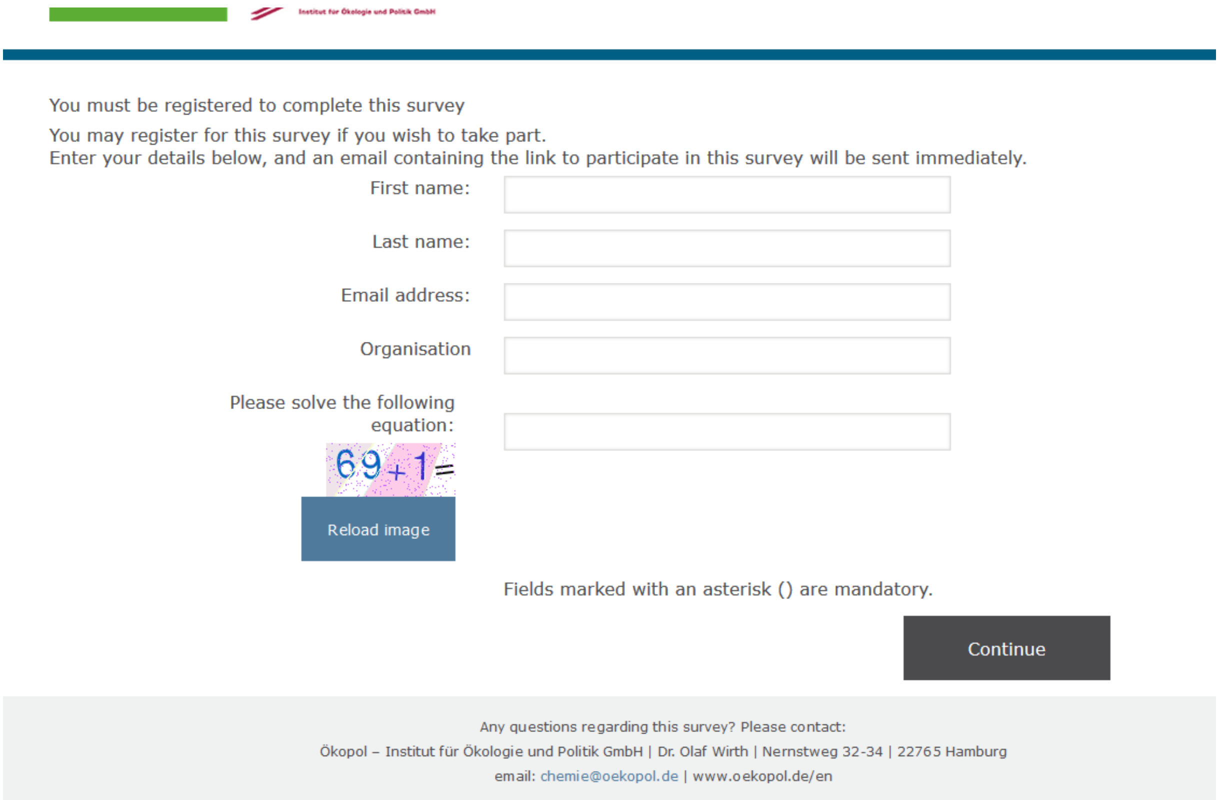
The website contained some short introduction on the background of the survey and some general instructions to the survey tool. The background part also contained a list of substances that might be in the scope of the restriction (e.g. extracted data from an RMOA supplemented with the C15-C20 PFCA, a background paper on the scope etc.). Such information was also available in a downloadable format (pdf or word document) in order to give potential data submitters the opportunity to download information and to involve other persons in the company, e.g. people with particular knowledge, but also decision makers that can decide if information should be submitted in the process. The portal layout was similar to the usual Ökopol corporate design (see Figure 2).

Figure 2: Screenshot of the Ökopol survey starting page (here from survey in phase 2)



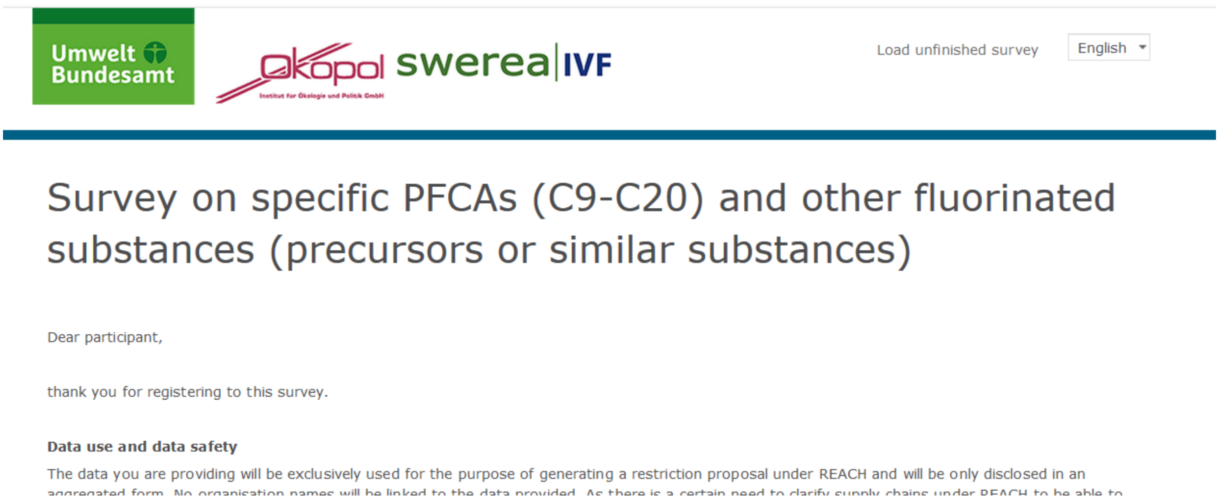
The actual registration to access a survey was then performed in the LimeSurvey tool. Registration consists of a very short data entry process (name, surname, e-mail) followed by a short text that indicates an e-mail has been sent which contains the "personal" link to the survey itself (see Figure 3.)

Figure 3: Registration fields to access a survey



The survey itself was designed using colour schemes of the UBA without coping the design of the UBA website completely to avoid the impression the participant is working on an UBA website/server (see Figure 4). The logos of all partners involved in the project have been integrated in the header. The starting page included some instructions how the survey works, how data are used and how data security is ensured.

Figure 4: Welcome page after registration (here from survey in phase 1)



It was possible to switch between language versions in the far upper corner to the right. Furthermore PDF versions of the questionnaires were provided for download. This was seen as essential, as many potential data providers have some interest to know in advance which data need to be provided. It can be resumed that this service resulted in some extra workload, since the integrated preview options of the tool are not very suited to match the minimum quality standards regarding layout of a professional tool, but are rather "working" versions for people that use this previews internally and do not mind a rather raw presentation. Therefore, extra PDF versions of the surveys were produced to provide the participants with versions that have an acceptable layout.

Layout was also an issue when participants completed the survey and had the intention to export their own data for documentation. There were various export options (besides PDF there were also possibilities to export data into XML, html, text files and some other specific formats). Here often the PDF or an HTML view were used, but both formats had some significant deficiencies. Here further work might be needed to implement a proper output format. This should in principle be possible since the open source structure of the programme itself does offer many options to adapt integrated formats, but this will need some additional development work.

4.1.2 Data security and handling of confidential data

Since a restriction proposal under REACH does involve data that are considered business sensitive, such an information collection via an online interface needs some considerations with regard to data security. The protection of data needs to have a main emphasis when surveys are asking for confidential information from specific stakeholders. To overcome potential concerns by stakeholders, a number of measures were taken that had the intention to ensure data security.

These were in detail:

- The server of the online version of LimeSurvey is located in the EU (Germany) and therefore under the validity of German Federal Data Protection Act. The access to this servers and the databases were addressed in contractual agreements with the service provider.
- Ökopol includes a disclaimer on data security on the survey website (starting portal for all surveys) - see box below. It should be noted that here a link was made to the UBA as the contractor. For future projects it should be evaluated carefully from the beginning, if exchange with other member state authorities, the ECHA or the EU-Commission is needed to be very precise on the distribution list.

Survey Data security declaration (taken from Ökopol website)[65]

Data safety and security

The data will be used by the German Environment Agency and Ökopol GmbH/Swerea IFV to develop a restriction proposal under REACH. The data you are providing is not anonymised when entered into the questionnaire, as we intend to organise a follow up interview process to clarify open issues that might occur upon the processing of the data you have provided. Data that becomes part of publically available documents are only used in anonymised and aggregated ways.

This survey is hosted by Limeservice GmbH, Barmbeker Str. 7a, 22303 Hamburg, Germany in accordance with § 9 of the German Federal Data Protection Act.

[65] https://www.oekopol.de/en/themen/chemikalienpolitik/umfragen/survey-on-specific-pfass-c4-c7-and-other-fluorinated-substances-precursors-or-similar-substances-to-develop-a-restriction-proposal-under-reach/

In practice many stakeholders that contributed to the survey (or rather contacted the consultants on the subject) were very reluctant to submit information they considered business confidential via an online tool. These stakeholders often stated that they are willing to contribute to an information collection but wanted to provide this information via other input pathways:

- Some companies wanted to discuss the subject of PFAS in face to face meetings. There was a high motivation to provide information in the surveys even if this would mean travelling for several persons to the consultant's facilities (sometimes from Asia or the US). This motivation was far higher in the second survey on the short-chain PFAS, presumably because the relevance of these substances is much higher for many companies than that of the C9-C20 PFAS, for which it was agreed in unison to discontinue the use (even the niche use).
- Some companies insisted to provide information via other channels. Following approaches were performed:
  - The consultants were provided with login information to an internal data exchange server from which the information could be downloaded via a secured connection.
  - Electronic documents were provided to the consultants. These were sometimes password protected. Others were provided as a read only version. This means they could not be printed, copied etc., which made it very hard to consolidate the data for further processing for the preparation of the Annex XV dossier. In such cases a person had to transcribe the information manually for further use. It has to be mentioned that in such cases the resulting document did not have the same protection level than the one received. Whether or not this is seen as a confidentiality issue is unclear. On the other hand it seems clear that the information if used in an Annex XV dossier need to be consolidated somehow and therefore copy protection must be seen as an unnecessary burden for the effective preparation of the dossier.
  - Hardcopy versions of documents have been sent to the consultants via mail. In such cases often reports or articles were provided to the consultants. This in principle can be valuable additional information, but makes the extraction of the relevant data requested extremely burdensome. Each document has to be assessed manually for data that are requested in the survey and are relevant for a restriction proposal. Often the documents contained only very few information that were seen central for the development of the proposal and contained many unnecessary parts.

4.2 Survey approach and content

In general, the surveys were designed to collect information on four subjects.

1. Substance identities of substances that are in the scope of the survey and tonnages placed on the EU market.
2. Presence of the substances in uses, processes and products, including some basic information on extend the substances are present in these areas (tonnage used by a company in a use, content in products, impurities).

3. Information on potential emissions via various pathways like waste, waste water and estimated tonnage that is released.
4. Availability of alternatives, cost for substitution and timelines by when substitution could be realised. Furthermore this section covered question on the economic impact of a potential restriction for the companies that were providing the data (e.g. market share of products produced with fluorinated chemicals or alternatives, turnover, number employees).

In the second survey on the short-chain PFAS there was also a section included with questions that addressed the restriction initiative as such and which are not necessarily specific to an individual company's situation (e.g. how high the risk of continued use of fluorinated compounds is evaluated if a restriction should be implemented at all, for specific uses etc.). Such a section seems necessary to evaluate the restriction proposal on a wider level. Stakeholders that are not directly affected, NGOs and associations often wish to provide more general effects, e.g. the impact on business areas, improvements for human health or the environment etc. that do not match the specific question type where hard facts are requested. Nevertheless, it seems important to understand the wider view on a specific initiative to be able to intensify research activities, when information seem uncertain.

These areas form the basis to be able to provide the information needed to prepare an Annex XV Dossier (see section 3 of Annex XV of the REACH text). Information are needed to define the scope of the restriction and to perform the risk assessments needed to justify a measure including the consideration of the socio-economic impacts. Since many restriction are triggered by the intrinsic properties of a substance and potentially on limited knowledge on the use areas, such an information collection can assist the evaluation of the substance on the EU market in total. This helps to elaborate a restriction proposal that in best case covers all existing risks in one go. Alternatively a proposed regulation is drafted that will only cover application areas where the information to demonstrate the risk are already available. Such an approach does not address the aim of REACH to control all risks that originate from a substance´s presence on the market in an optimised way:

- Relevant risks might be overlooked due to a lack of information only.
- Keeping information confidential and not sharing them with authorities is "awarded", because a restriction will not be issued.
- Innovations may be prevented from introduction on the market since older technologies that might cause a risk are not regulated.
- The process is not very efficient for the authorities, because each time new information become available that indicate a risk may be present from that substance´s presence on the market, they will need to start an individual new restriction proposal.

The following sections of this report will not cover the specific questions that were issued in the two surveys but the approaches that have been followed to get the information in an efficient way. Before this discussion is presented in a bit more detail, some remarks have to be made on the substances that were covered by this specific survey.

4.2.1 Surveys on fluorinated substances - general observation on the selection of substances for the information collection

Whenever fluorinated substances are discussed, a high level of uncertainty is linked to the debate what substances are really covered. Many different terms are used to address different substances or groups of substances. A very brief and concise overview on this question is given in the OECD synthesis paper on per and polyfluorinated chemicals[66]. Another initiative on the OECD level that aimed to list PFAS-related substances via its CAS numbers listed a total of 4730 different compounds[67]. These publications give a good impression on the high complexity within this substance group. For an IT-based survey, this complexity causes some impacts that should be discussed here.

In both surveys, the substances that were intended to be addressed by the restriction proposal later on were not defined conclusively.

In the first survey, the scope was defined by a core group of 12 substances (C9-C20 PFCA), their salts and precursor substances. Latter cover an undefined number of substances that can - during their life cycle - result in the generation of the 6 substances (C9-C14) that are the core target of the envisaged restriction proposal.

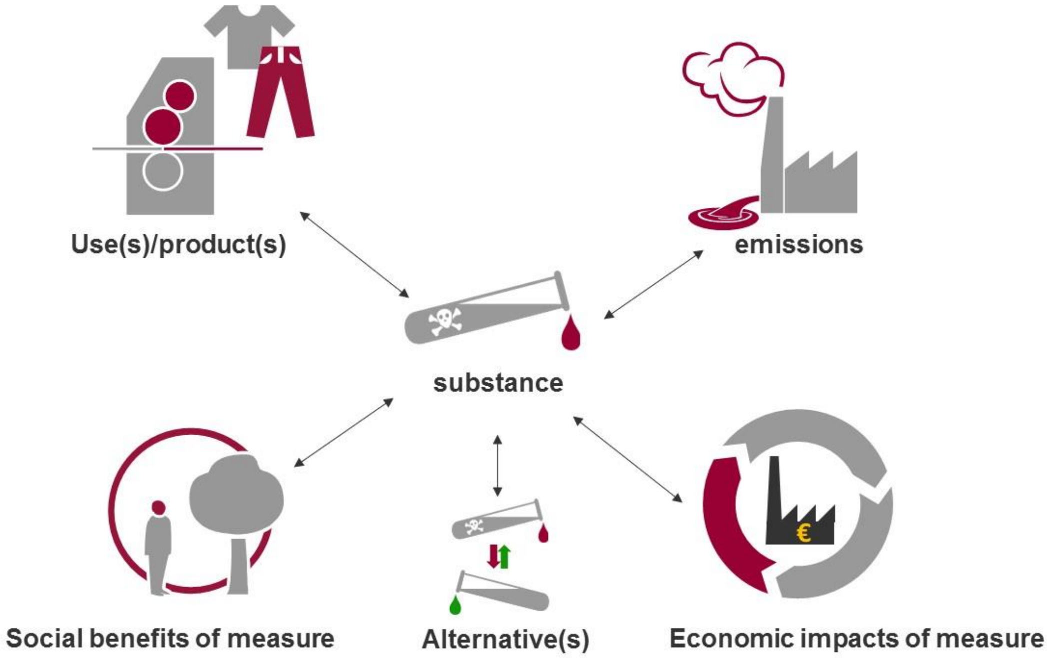
This definition of the scope for the second survey (short-chain PFAS) was even broader and less defined than it was for the first survey with the following implications for the survey. When a survey is issued for one substance only the relation of the information provided and the substance can be established very easy. Each answer refers directly to the substance under discussion (see Figure 5). Such a relationship can be reflected in a questionnaire in a straightforward way, e.g. first one can ask for the tonnage (substance ID is already defined in such cases) then for the uses and emission and then link these to the socio-economic data and potential alternatives. This becomes more complicated when the number of substances for which the information are collected is higher. For a small number of substances it is possible to repeat the different sections of the questionnaire.

First, the information on the substance ID can be entered together with information on tonnages. If there is the intention to provide information for a second substance one can implement a repetition in the IT-tool. The user just klicks a button "add another substance" and the same data entry fields are repeated. After this, the data entering options for uses and the other information areas are opened automatically for each of the substances that have been entered in the first section. On an IT level this can be easily implemented as long as the number of substances that can be entered as a maximum is clear. If e.g. at maximum 10 substances are part of a group this can be foreseen in the tool (and in the underlying database). The survey participant does not see 10 times the sections but only for as much substances as he or she has entered data in the first step. Hence, the questionnaire is not getting lengthy on the screen. It is furthermore possible to allow the user to switch between the sections. In principle as many questionnaires are filled in as the participant has information for.

[66] OECD (2013), OECD/UNEP Global PFC Group, Synthesis paper on per- and polyfluorinated chemicals (PFCs), Environment, Health and Safety, Environment Directorate, OECD. https://www.oecd.org/env/ehs/risk-management/PFC_FINAL-Web.pdf

[67] See inventory prepared in the project "Toward a New Comprehensive Global Database of Per- and Polyfluoroalkyl Substances (PFASs)". http://www.oecd.org/chemicalsafety/risk-management/global-database-of-per-and-polyfluoroalkyl-substances.xlsx (OECD 2017) and the related methodology report OECD Environment, Health and Safety Publications Series on Risk Management No. 39 TOWARD A NEW COMPREHENSIVE GLOBAL DATABASE OF PER- AND POLYFLUOROALKYL SUBSTANCES (PFASs): SUMMARY REPORT ON UPDATING THE OECD 2007 LIST OF PER- AND POLYFLUOROALKYL SUBSTANCES (PFASs) (OECD 2018) http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=ENV-JM-MONO(2018)7&doclanguage=en

Figure 5: Relationship substance - information collected



Source: own illustration Ökopol

This relation becomes more difficult if the number of substances is undefined. For this cases the maximum number of repetitions cannot be pre-defined and an option has to be implemented that allows participants to provide information for a higher number of substances. In the survey on the short-chain PFAS some participants provided information for about 20 substances. In the surveys on the PFAS this was anticipated and an EXCEL data sheet was offered that could be used to include the information on the substances and upload them. Some participating companies used this offer. A side effect of this solution is that such a datasheet can often be filled automatically with the reports that can be generated out of internal IT systems of companies.

While there are good solutions to collect information on each of the areas addressed, another problem that is seen when IT-based information collections are used for a high number of substances is to understand the links between the different areas when data are analysed. It can e.g. be that case that an alternative can be a substitute for one of the substances, but not for others. This is difficult to reflect in an online questionnaire when the input substances are not completely clear. There can be solutions found for this problem on a programming level, but standard tools are not suited to provide easy solutions for such questions and are better applicable for a lower number of substances.

Having this observation in mind, some more specific issues on the data collection in the various information areas are discussed in the following chapters.

4.2.2 Substance ID and tonnages placed on the market

4.2.2.1 Information collection on substances - manufacturer and importer

Based on the general considerations on number of substances two basic approaches were implemented to collect information of substances placed on the market and the tonnage.

In the first survey the main focus was on the C9-C20 PFCA. These substances were seen as a “core group” of the data collection. Therefore we designed the questions in this section of the survey in a way that the user could enter tonnage data and the technical function directly into a matrix (see Figure 6). Besides an exact value for the tonnage it was also possible to provide ranges, either because no exact values are available to the companies or if they want to treat the exact number to be a trade secret.

Figure 6: Screenshot of data entry matrix on substance data from Survey on C9-C20 PFCA

Manufacturer/Importer of Substances

Specific substances (C9 - C20 PFCAs)

Are you manufacturing/importing one of the following substances? If so, please provide data on the avarage tonnage you manufacture/import (as an avarage value or as range per year) and the possible technical function/s of the substance.

If not, please go on specifying which other substances you manufacture/import in the next section and leave these fields blank.

	tonnage avarage value [kg/year]	~ tonnage min [kg/year]	~ tonnage max [kg/year]	technical functions
PFNA, Perfluorononan-1-oic acid (C9-PFCA), CAS 375-95-1				
PFDA, Nonadecafluorodecanoic acid (C10-PFCA), CAS 335-76-2				
PFUnDA, Henicosafluoroundecanoic				

In addition to this matrix, the participant had the option to add other substances that were not known in advance to the survey (see Figure 7). This option was limited to a maximum of five additional substances. For more substances an EXCEL sheet was offered for download to provide the information in a structured way.

Figure 7: Optional input question for substances not in the "core" group of C9-C20 PFCA

Manufacturer/Importer of Substances

Substance specification

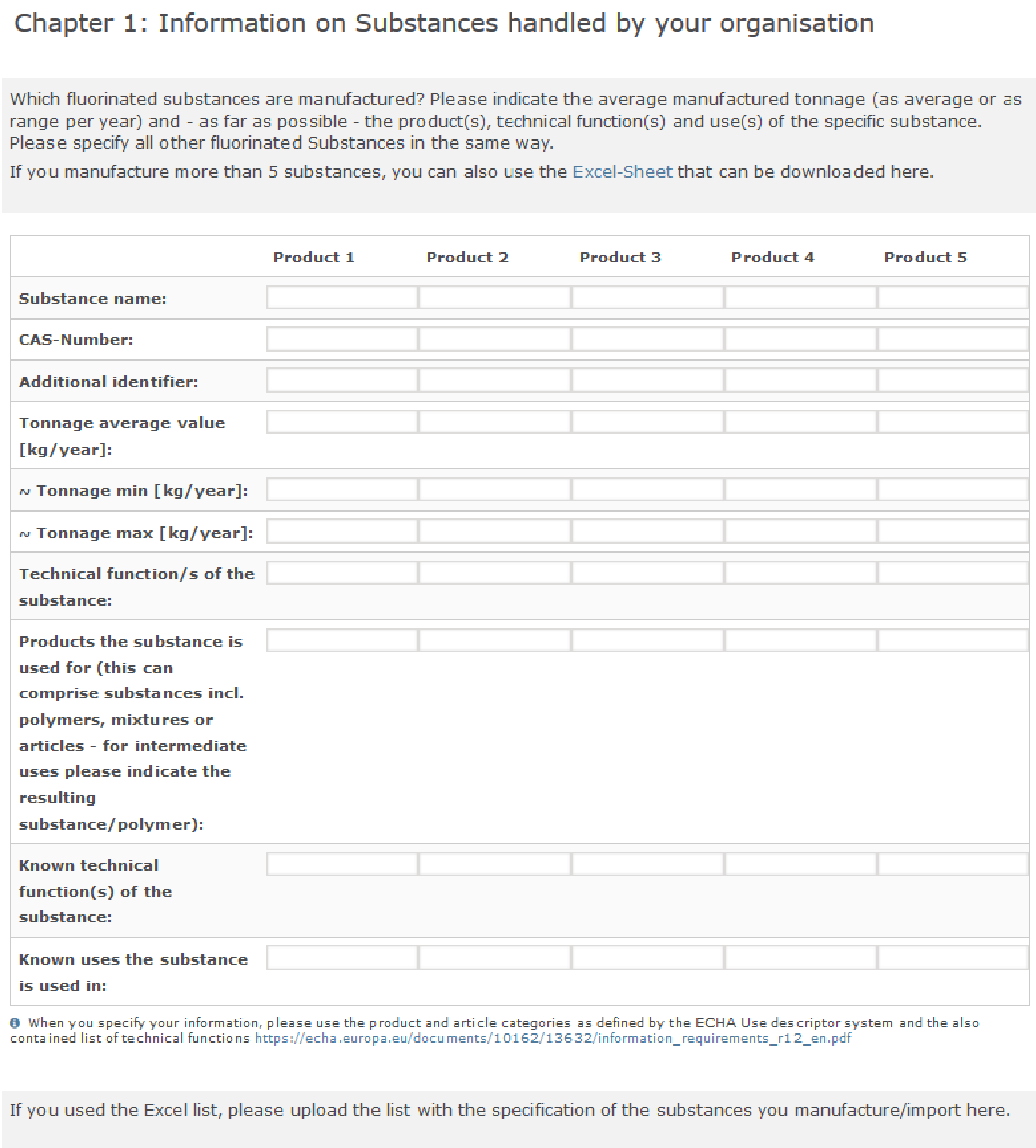
Please specify any substances you manufacture/import.

If you manufacture/import more than 5 of these substances please download this Excel-Sheet (SubstancesList.xls) and provide as much information on the substances as possible. You can take as much time as you need to fill out the list and come back later to upload it below and leave the follwing lines blank.

Substance name	
CAS-Number	
Additional identifier	
Tonnage average value [kg/year]	
~ Tonnage min [kg/year]	
~ Tonnage max [kg/year]	
Technical function/s of the substance	

In the second survey on the short-chain PFAS, no core group existed as in the first survey on the long-chain PFCA. Therefore, no set of specific substances could be defined that could assist the user to understand which substances should be covered in the information collection. It was unclear from the beginning for which specific substance information could be expected. Therefore, no predefined substance options were provided to the participants. Overall, there were more possibilities to provide free text information to allow the user to reflect his situation in an adequate way. Furthermore, a direct link to the uses of the substances was included in the matrix. Again, there was the opportunity to provide information via EXCEL instead of entering the data directly in the survey (see Figure 8).

Figure 8: Screenshot of data entry matrix on substance data from Survey on short-chain PFAS


Chapter 1: Information on Substances handled by your organisation

Which fluorinated substances are manufactured? Please indicate the average manufactured tonnage (as average or as range per year) and - as far as possible - the product(s), technical function(s) and use(s) of the specific substance. Please specify all other fluorinated Substances in the same way.

If you manufacture more than 5 substances, you can also use the Excel-Sheet that can be downloaded here.

	Product 1	Product 2	Product 3	Product 4	Product 5
Substance name:					
CAS-Number:					
Additional identifier:					
Tonnage average value [kg/year]:					
~ Tonnage min [kg/year]:					
~ Tonnage max [kg/year]:					
Technical function/s of the substance:					
Products the substance is used for (this can comprise substances incl. polymers, mixtures or articles - for intermediate uses please indicate the resulting substance/polymer):					
Known technical function(s) of the substance:					
Known uses the substance is used in:					

When you specify your information, please use the product and article categories as defined by the ECHA Use descriptor system and the also contained list of technical functions https://echa.europa.eu/documents/10162/13632/information_requirements_r12_en.pdf

If you used the Excel list, please upload the list with the specification of the substances you manufacture/import here.

4.2.2.2 Information collection on substances - downstream users

When information on substances and tonnages were collected among the DUs a slightly different approach was taken based on the following considerations:

- Knowledge of DUs on the chemistry used for processes can be limited. This might vary between the different types of DUs (e.g. a formulator might have a significantly better understanding than an end user who applies a mixture containing one or more PFAS).
- The understanding of the "downstream process" is the core competence of this stakeholder group. Therefore, it should be ensured that this is the starting point of the information collection, rather than the exact determination of a substance identity. This ensures the participant can give answers in the beginning and has the motivation to provide the information he or she has. Starting with questions that potentially cannot be answered might result in the termination of the information collection already at the beginning and information that potentially were available will not be submitted.

Based on the two considerations the questions for formulators or end users were arranged in a different way (see Figure 9). At a first stage, we asked the DUs what type of products are produced (formulators) or in which processes fluorinated substances are used (end users). When end users were involved it was also distinguished whether substances are incorporated in other products (e.g. articles) or the fluorinated substances are used in processing aids. Furthermore, we asked for the substance identity (also giving the option to use trivial names) and mixture concentrations.

Figure 9: Screen shot of data collection section information on substances and mixtures for formulators

	Product 1	Product 2	Product 3	Product 4	Product 5
Substance name:					
CAS-Number:					
Additional identifier:					
Tonnage average value [kg/year]:					
~ Tonnage min [kg/year]:					
~ Tonnage max [kg/year]:					

NOTE: This survey covers lower molecular weight fluorinated substances as well as polymeric substances that make use of such lower molecular building blocks. Please specify any substances you supplied with.

Please provide us some information on the products you formulate. You can enter data for up to 5 product (types), if you want to submit information on more products, please use the excel sheet you can download here.

	Product 1	Product 2	Product 3	Product 4	Product 5
Product the substance is used in:					
Technical function(s) of the substance:					
Uses the mixture is used in:					
Concentration/s in formulated Product(s) [w/w%]:					
Concentration/s range min [w/w%]:					
Concentration/s range max [w/w%]:					
Product name:					
Additional product information (e.g. brand):					

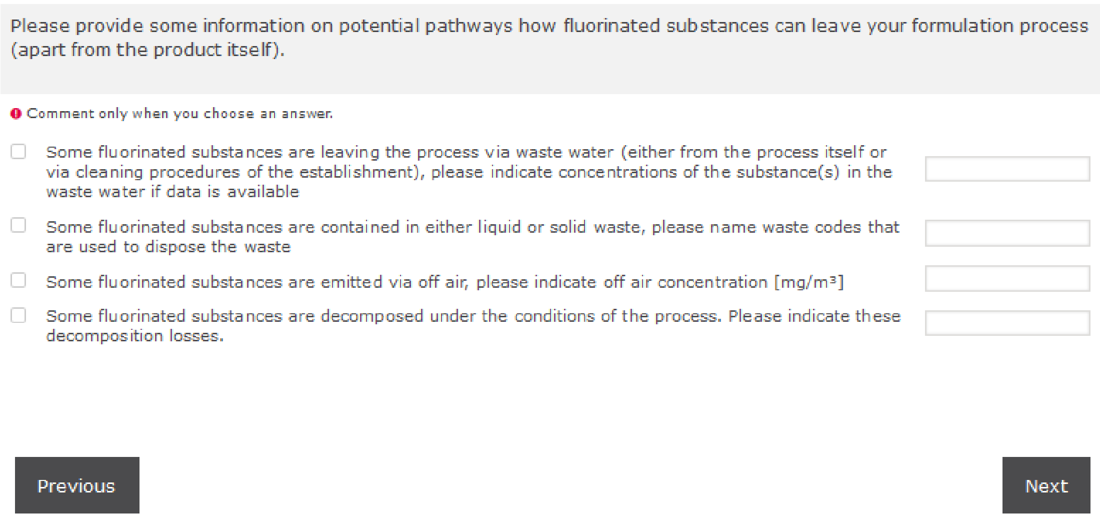
Whenever you specify your information, please use the product and article categories as well as technical functions as defined by the ECHA Use descriptor system (https://echa.europa.eu/documents/10162/13632/information_requirements_r12_en.pdf)

In the first survey some questions were also included that were based on pick lists. One question e.g. covered the product categories of the use descriptor system as laid down in the ECHA Guidance document "Guidance on Information Requirements and Chemical Safety Assessment Chapter R.12: Use description". Such list are easy to use for participants, as the effort for data input is limited and the information can often directly be retrieved form product documentation like the safety data sheet. Nevertheless, these type of questions have limited value for the data collection, as they result in very large databases. Furthermore, it is not the aim to describe a set of companies statistically. It is e.g. not relevant what the share of companies is that produce a certain type of products. Numbers are usually so low that a comparison of absolute numbers is sufficient to understand the relations in a sector. More important in the context of REACH restrictions is the possibility to estimate the risk level and the impacts on companies. Therefore, this type of question was not used in the second survey. It was still possible to provide the use descriptors but here via free text descriptions. This also allowed the participants to use a terminology other than defined for REACH purposes.

4.2.2.3 Information collection on uses and emissions

The collection on information regarding the uses and the potential emissions[68] from these uses was focussed on the categorisation of these subjects to understand the extent these uses are performed. The categorisation should furthermore assist the survey participants in the entry of the data. They could select from pre-defined options to describe their specific use and potential emission sources. Figure 10 gives an example how categories could be used to describe the formulation process. In some cases, as e.g. in the case of the potential release from the process, a further specification in the form of a free text input field was needed.

Figure 10: Categories to describe a formulation process in questionnaire (production mode, potential emissions)



Please provide some information on potential pathways how fluorinated substances can leave your formulation process (apart from the product itself).

Comment only when you choose an answer.

- Some fluorinated substances are leaving the process via waste water (either from the process itself or via cleaning procedures of the establishment), please indicate concentrations of the substance(s) in the waste water if data is available
- Some fluorinated substances are contained in either liquid or solid waste, please name waste codes that are used to dispose the waste
- Some fluorinated substances are emitted via off air, please indicate off air concentration [mg/m^3]
- Some fluorinated substances are decomposed under the conditions of the process. Please indicate these decomposition losses.

Previous

Next

This approach to collect the data was perceived as very easy for the participants and was used in both surveys. In the second survey an additional question was included that addressed the PFAS specific installed risk management measures. This was a free text entry field as the range of technologies can vary broadly and may be specific to the installation and/or process.

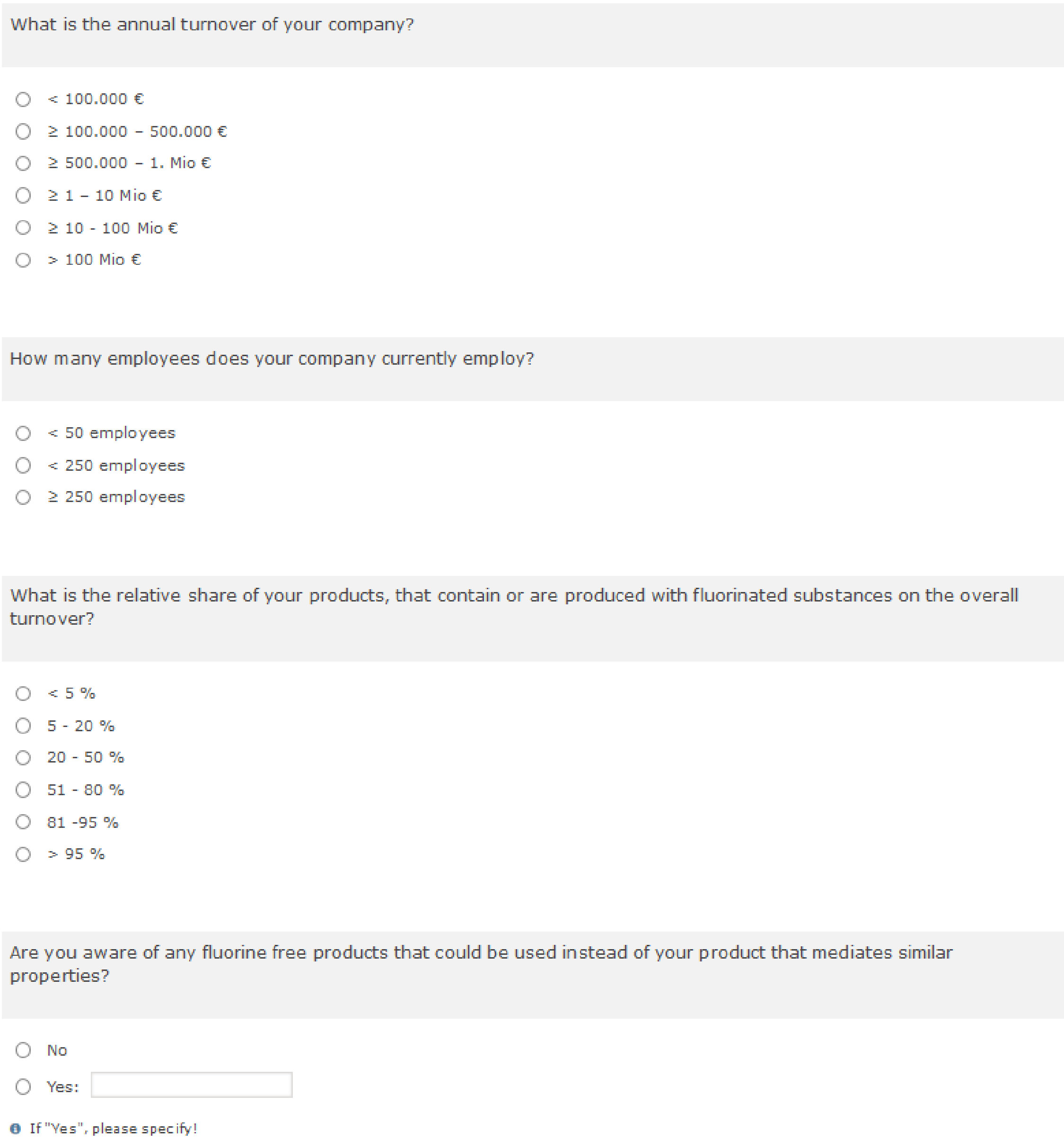
4.2.2.4 Information on socio-economic effects of the restriction and substitution

The section on socio-economic effects and substitution were approached in a similar way the information for uses were collected. Again, most of the questions were based on categories to collect the responses by stakeholders. A first question series was used to qualify the organisation of the participant with some key information on turnover and employed persons. This also included a quantification of the relative share products that rely on fluorinated compounds (see Figure 11). These data were provided in almost each case in which participants responded to the survey. The same was true for other questions in these section (e.g. the share of products produced with alternatives already, cost differences in production when alternatives

[68] Since it was not part of the project to extract such information from other documents like e.g. registrations this is not discussed here. Furthermore, only limited information are available as only very few substances are registered and here often as intermediates, only. As a result such data are lacking systematically for PFAS

are used, general view on technical and economical substitution potential and timelines envisaged for substitution (sometimes theoretical as a minimum timeline to find alternatives and also the overall estimated cost for a transition).

Figure 11: Basic economic data collected


What is the annual turnover of your company?

- < 100.000 €
- ≥ 100.000 – 500.000 €
- ≥ 500.000 – 1. Mio €
- ≥ 1 – 10 Mio €
- ≥ 10 - 100 Mio €
- > 100 Mio €

How many employees does your company currently employ?

- < 50 employees
- < 250 employees
- ≥ 250 employees

What is the relative share of your products, that contain or are produced with fluorinated substances on the overall turnover?

- < 5 %
- 5 - 20 %
- 20 - 50 %
- 51 - 80 %
- 81 -95 %
- > 95 %

Are you aware of any fluorine free products that could be used instead of your product that mediates similar properties?

- No
- Yes:

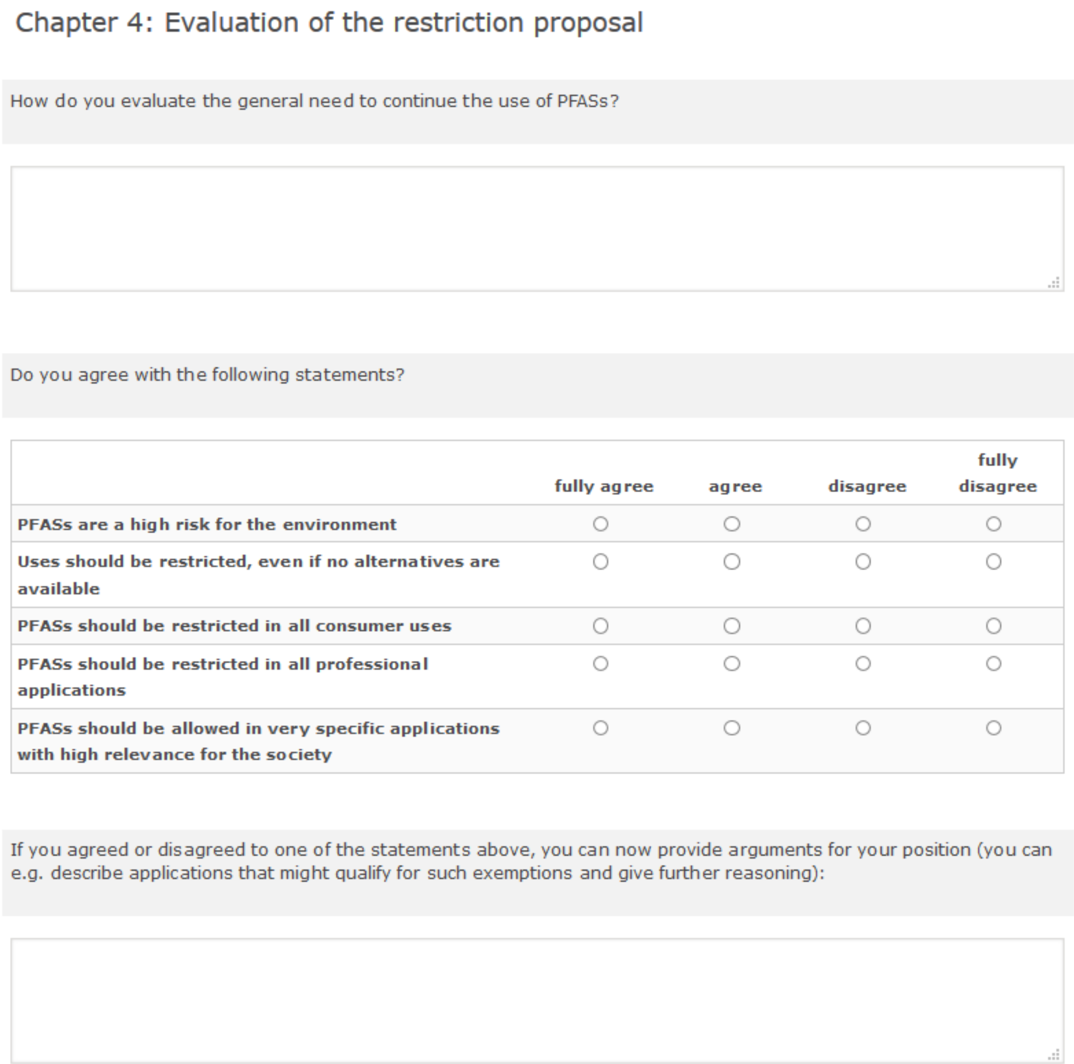
If "Yes", please specify!

This section showed that the usability of categories (e.g. ranges) to describe the situation of stakeholder can be very useful. The categories also help to keep certain information confidential (ranges are also often used in socio-economic analysis for applications for authorisation towards the public). This makes it easier to describe the companies' situation (no exact data need to be retrieved beyond usually available information).

4.2.2.5 Additional information on the envisaged restriction

In addition to the specific data on substances, uses, economic effects and alternatives, questions were issued that are related to the overall evaluation of the restriction intention. In case of the NGOs/associations these questions were the main scope of the information collection and formed an own survey. In the other questionnaires they were included as an additional final section. Since these questions were expected to be answered by some additional rationale that can vary between organisations contributing, free text questions were mainly used. It was furthermore possible to upload documents in this part of the survey (see Figure 12). Such documents could be any additional information stakeholders might find useful to inform the survey (and in the end the authorities), as there are scientific papers, position papers, meta-data for sectors etc.

Figure 12: General questions on the restriction initiative



Chapter 4: Evaluation of the restriction proposal

How do you evaluate the general need to continue the use of PFASs?

Do you agree with the following statements?

	fully agree	agree	disagree	fully disagree
PFASs are a high risk for the environment	○	○	○	○
Uses should be restricted, even if no alternatives are available	○	○	○	○
PFASs should be restricted in all consumer uses	○	○	○	○
PFASs should be restricted in all professional applications	○	○	○	○
PFASs should be allowed in very specific applications with high relevance for the society	○	○	○	○

If you agreed or disagreed to one of the statements above, you can now provide arguments for your position (you can e.g. describe applications that might qualify for such exemptions and give further reasoning):

4.3 Conclusions

On a very general level it is not very easy to compare the two surveys performed in the frame of the project. While in the first survey only very few participants contributed, a higher number of responses was collected in the second one. Considering the answers received in the subsequent interviews the main reason for this might be the far lower relevance for stakeholders of the C9-C20 PFCA compared to the short-chain PFAS issued in the second survey. There was no indication that a restriction of C9-C20 PFCA and related precursor substance will have any effects on any processes and products in the EU, as these were not actively used. In the past they have mainly been present as impurities in other PFAS, especially the PFOA. With the restriction of this substance many producers of fluorinated compounds shifted towards C6 chemicals. In the manufacture of these substances it was necessary to separate the PFOA to comply with the new restriction and in this process the longer chained compounds were also separated and thereby eliminated from production.

Nevertheless, some general conclusions can be drawn from the experiences and approaches tested in the two surveys.

The first and most important is that the scope of the information collection has been already defined substance wise. An analysis of the substances that cause a risk should be separated from the collection of information on the uses of the available alternatives and socio-economic effects on stakeholders. It must be clear from the beginning which substances are covered by an information collection to make it possible for information holders to identify the relevance of an activity for their business. It should be mentioned in this regard that the problem is not the absolute number of substances that are covered by an information collection. More important seems to be, that a conclusive list can be used to set up a survey. One should be very clear on which substances the information is being collected. Then it is possible to programme the IT-tool in a way that data can be sufficiently collected in a structured way.

However, this structuring has its limitations when it comes to the description of dependencies between different substances and uses. In the particular case of the short-chain PFAS it was often the case that one compound was used to produce one or more other compounds. These were often - but not always - polymers that might be covered by the precursor definition and thereby in the scope of the initiative.

Structuring was very helpful in cases when clear parameters could be asked for and it was possible to define numerical categories. Companies seemed to have a very good understanding of their relative structure (e.g. what is the size of a batch, how often do we produce a product, what is the average turnover and the contribution of the product line with fluorinated products or the ones with alternatives). Nevertheless, companies often indicated that they would prefer other ways of contributing to an information collection based on following reasons:

- Data security: Some companies stated that a submission of potentially confidential data via the internet on a third party server would not be acceptable.
- Complexity of information: Some companies stated that their specific situation might be too complex to be reflected in a questionnaire.

In general it was attempted to minimise the efforts to be taken for completing such a survey and to evaluate the submitted information. The experiences with the efforts for setting up the survey and observation from the responses indicate that some information areas on uses and economic data can be standardised very well by making use of categories. This makes it very easy for the participants of the survey to provide the data and furthermore reduces the reservation to provide business sensitive information. In other areas, the possibility for standardisation depends largely on the extent the intended restriction is already defined when the information collection is started. If a group has an unclear scope, as it has been the case in the two surveys, it is necessary to provide input options that allow the survey participants a variety of answers (usually this increases the use of free text answers).

A Appendix Literature Study on C9 – 14 PFAS

A.1 Introduction

Poly- and perfluorinated alkyl substances (PFAS) is a term used for a wide variety of substances that have been identified as an emerging topic for concern during the past 15 years. Initial research and measures addressed specific compounds such as PFOS and PFOA. PFOS is listed in the Annex B document to the Stockholm convention since 2010; for PFOA, the US EPA initiated a global product stewardship program in 2006. As restrictions and other measures were established, substances with a perfluorinated chain length other than eight were used as alternatives. Some of them are also subject of activities. Perfluorinated carboxylic acids (PFCA) with a chain length C9 to C14, which include perfluorononanoic acid (PFNA), perfluorodecanoic acid (PFDA), perfluoroundecanoic acid (PFUnA), perfluorododecanoic acid (PFDoDA), perfluorotridecanoic acid (PFTrDA), and perfluorotetradecanoic acid (PFTeDA) are listed on the candidate list for substances of very high concern provided by the European Union's chemical agency (ECHA).

This section of the report focuses on literature for PFCA with a chain length above eight and mostly up to 14, compounds with even longer chain length are included in the search results but not addressed in the query. All search results are explored for examples of usage in products and production processes that can contribute to a better knowledge on potential pathways.

A.2 Background

The carbon–fluorine bond is very strong and the perfluoroalkyl moiety, –CnF2n+1 is characteristic for linear and branched fluoro chemicals that are described as per- and polyfluorinated chemicals abbreviated PFAS. Cyclic PFAS are characterized by the perfluoroalkyl moiety; –CnF2n and polyfluorinated chemicals do not contain any perfluorinated moiety (e.g – CHF-). PFAS include a vast number of substances with varying chemical structures and technical performance (Buck et al., 2011). A range of these variants of PFAS are described in this report, and scientific publications and reports that refer to this type of substances are summarized.

Because of the wide variety, mapping potential applications and sources of PFAS in the environment needs considerable effort. Nomenclature and terminology is varying. Group designations such as "long-chain" are established and used by the OECD and other institutions, such as US EPA and Flourocouncil to specify a cut-off:

- Perfluorocarboxylic acids (PFCA) with carbon chain lengths of 8 and higher, including perfluorooctanoic acid (PFOA)
- PFSAs with carbon chain lengths of 6 and higher, including perfluorohexane sulfonic acid (PFHxS) and perfluorooctane sulfonate (PFOS)
- Precursors of these substances that may be produced or present in products. A "precursor" means a substance that has been recognized as having the potential to degrade to the above substances, such as long-chain fluorotelomer-based raw materials (FTOH).

- Polymeric and non-polymeric fluorotelomer-based chemicals made from long-chain flurorotelomer-based raw materials belong to the class of long-chain PFAS.

The regulatory concerns on chain terminology started in 2006 when parts of the global fluorochemical industry together with the US EPA formed the 2010/15 Stewardship Program[69]. In this context it was important to specifically describe those substances ("long-chain") that were the subject of regulatory action and industry action (the termination of the manufacture and use of PFOS, PFOA, their precursors and higher chain homologues. The term "long-chain" linked to the specific chemical structure descriptions which clearly delineated the substances that were the subject of regulatory action and industry action.

A common property of per- and polyfluorinated non-polymers is their surface activity. The performance attributes of fluorinated surfactants are unique and distinguish them from other types of surfactants. Fluorinated surfactants are relatively costly and therefore are generally only used because no other alternative surfactant (e.g. hydro-carbon, silicone) can deliver the required performance due to their surface activity in both aqueous and solvent systems (Knepper and Lange, 2012). In addition, fluorinated surfactants are effective in organic solvents including esters, alcohols, ethers, and solvent-based resin systems. Additionally the reduced surface tension achieved by using fluorinated surfactants results in good wetting, spreading, and levelling properties for all types of surfaces, e.g. hard surface, wet surfaces, plastics, wood, porous surfaces and even oily metals.

Fluorinated surfactants can lower aqueous surface tension to less than 16 dynes/cm and function at very low concentrations (e.g. 100–500 mg/L). They are effective in both basic and acidic aqueous media.

They are effective emulsifiers in specialty applications where fluorinated materials are in either the dispersed or continuous phase (e.g. synthesis of fluoropolymers), where salts of PFOA, mainly the ammonium salt of PFOA (APFO), are originally used as emulsifiers for fluoropolymer production. Current replacements to APFO are a range of perfluorinated ethers.

Finally, perfluorinated sulfonic and carboxylic acids are very stable both chemically and thermally. Because of their very low aqueous surface tension, fluorinated surfactants are used in applications including firefighting foams, paints, coatings, mining, paper, electroplating, photographic emulsifiers, pressure sensitive additives, waxes, polishes, insecticides, mold release, ink jet printing, lithography, enhanced oil recovery (EOR), and emulsion polymerizations, etc.

The critical micelle concentration (CMC) of a fluorinated surfactant is close to that of an ordinary hydrocarbon surfactant whose chain length is about 1.5 times longer than a fluorocarbon chain. However, fluorinated surfactants with longer fluorinated hydrophobic/oleo phobic chains, for example, greater than eight fluorinated carbon atoms, have reduced water solubility which limits their reduction carbon atoms have reduced water solubility which limits their reduction. This means that eight perfluorinated carbons have optimal functionality from a surfactant perspective on low surface tension (Knepper and Lange, 2012).

[69] https://www.epa.gov/assessing-and-managing-chemicals-under-tsca/20102015-pfoa-stewardship-program-2014-annual-progress#backgroundu

A.3 Literature search and results

Current collections give a cursory overview of usage, it is however not possible to determine whether a specific application is still up-to-date and if so, what are tonnages used for a specific usage. These data are potentially not available in literature but have to be collected through surveys and interviews. The literature search is therefore supposed to contribute to a raw list of potential usage and applications which can then be used as a base for purposeful further data collection.

Search engines used were Scopus, for scientific publications in peer-reviewed journals and mostly the Bielefeld Academic Search Engine (BASE), for publications in peer-reviewed journals and in reports published worldwide. BASE includes among others the Swedish portal DiVA (Digitala Vetenskapliga Arkivet, in English digital scientific archive) for reports from Swedish and Norwegian research institutions and authorities. BASE links also documents that are listed in the CiteSeerX library hosted at the Pennsylvania State University. The database includes open access publications and publications in journals which require a subscription.

All search queries were started as simple queries, without limiting hits to a certain period. Hits in English were considered, other languages preferably if there was a translation available or if the language was German, Swedish or Norwegian. Automated translations were not considered. Titles for all search results were screened to exclude those that used the same abbreviation for another topic.

In the following sections, search hits are summarized with ascending number perfluorinated carbon atoms, starting with C9. Articles that address other subjects than usage are not listed in their entirety, but some examples of topics are listed to give an overview.

For PFNA, the highest number of search hits was found. Articles dealt with observations of PFNA in the environment and in humans levels of PFAS in blood plasma (Kannan et al., 2004; Kärrman et al., 2006, 2004), tissue (Ericson et al., 2008) and breastmilk (Kärrman et al., 2007). Dietary intake as a potential pathway is an area of research (Rylander et al., 2009). Another area of research are potential toxic effects on a wide variety of different species mostly in aquatic environments and soil such nematodes (Tominaga et al., 2004), or seals (Vijver et al., 2005). Research also addresses possible environmental pathways such as atmospheric degradation of fluorotelomer alcohols (FTOH) (Ellis et al., 2004). Observations in water bodies were also reported in a study mapping concentrations in northwest Mediterranean coastal waters (Sánchez-Avila et al., 2010). Another topic that was addressed is analytical methods to detect PFNA and treatment methods to remove PFNA from waste water (activated carbon and membrane). A link between discharges from fluoropolymer, specifically fluorotelomer polymer production and polyvinylidene fluoride (PVDF) production and contamination was investigated in one publication by French researchers (Dauchy et al., 2012), the location of the production plants is not disclosed in the publication on grounds of confidentiality. For the case of the PVDF production it is possible to find the map of sampling locations in Lyon. Dauchy et al. (2012) write that: "Fluoropolymer manufacture is the single largest known source of PFNA and PFOA emissions in the environment" and refer to a publication on Sources, Fate and Transport of Perfluorocarboxylates (Prevedouros et al., 2006). However, this study was updated and republished (Wang et al., 2014) with PFNA addressed also in the updated version. The authors estimate that (1) PFNA manufacture, (2) PVDF manufacture with PFNA and use and (3) disposal of PVDF dispersions containing PFNA are direct sources. The estimated amounts are between 20 to 180 tonnes for (1), 270 to 1270 tonnes for (2) and 0 to 20 tonnes for (3) be-tween 1951 and 2002. For the period between 2003 and 2015 estimated amounts are 0 to 20 tonnes for (1) and 30 to 220 tonnes for (2), 0 tonnes for (3). From 2016 onwards, the estimated emission amounts are zero for all three potential sources. FluoroCouncil states for all members (includes potentially the French location) that PFNA is no longer used in PVDF production, which is in line with the global emission inventory.

References to applications and use of PFNA are otherwise sparse; a Swedish summary report lists use (of PFAS in general) as impregnating agents for clothing and textiles, as coatings for paper and packaging, in waxes and cleaning agents, insecticides, firefighting foams and hydraulic fluids in airplanes (Borg and Hakansson, 2012). The report also refers to a publication that lists 36 uses of PFAS ; none of the cases where a specific species is listed refers to PFNA (Järnberg et al., 2005). A study on occupational exposure to fluorinated ski wax found elevated levels of PFNA in blood, which also increased for some individuals during the skiing season; the study suggests that the principal source and pathway cannot be elucidated from the data, direct exposure to aerosols is one explanation. A comprehensive study on perfluoroalkyl and polyfluoroalkyl substances in consumer products lists PFNA in nanosprays and impregnation sprays, outdoor textiles, carpets, gloves, paper-based food contact materials, ski wax and leather. The same study also reports that PFDA, PFUnA, PFDoDA, PFTrDA and PFTeDA were detected in the aforementioned consumer products. Additionally, PFUnA, PFDoDA, PFTrDA and PFTeDA were detected in awning textiles (Kotthoff et al., 2015). An occupational exposure study for barbers and textile workers in China showed higher levels of PFNA, PFOA and PFOS in the blood samples of the latter (Lu et al., 2014).

Among the search results for PFDA were reports from as early as 1983, considering high values for acute toxicity on mouse lymphoma cells (Andersen et al., 1983). Related research was published for the following 10 years, whereas newer publications did shift focus. Observation of PFDA concentrations in marine species and in human blood and tissues, as already listed for PFNA, are an area of research from 2004 onwards. One publication describes a potential application in producing self-assembled monolayers (SAM) as a surface treatment method (Hoque et al., 2007).

Research on PFUnDA and PFDoDA showed up less frequently compared to the homologues with shorter perfluorinated chain length. The search results covered areas such as observations in the environment and different species and effects on organisms. No search results were related to use and industrial applications.

The results lists for both PFTrDA and PFTeDA were the shortest of all explored variants with less than ten hits for each.

All search results for PFTrDA were for environmental pollutants in large Norwegian Lakes and refer to a single report from 2014; the alternative abbreviation PFTriA lead to a different set of search results which cover observations in different species in Sweden and the Arctic regions and American Alligators.

For PFTeDA only a small number of search results are available, which cover observations in different species in Sweden and the Arctic regions.

An additional search for the term PFCA as a generic term led mostly to search results that were already covered in the searches for specific chain lengths. Additional topics were desorption from soil that has been contaminated with AFFF, predominantly on military sites and training sites for firefighters (Azzolini, 2014). Among the homologues analysed are PFNA and PFDA. As additional precursors polyfluoroalkyl phosphate esters (PAP) were addressed, which are used in food contact papers (D’eon and Mabury, 2011). In summary, the generic term was to a larger extent used in research on precursors and pathways.

A.4 Bibliography for Literature Study on C9 – 14 PFAS

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B Appendix short-chain PFAS for which the status in March 2019 is pre-registration according to the ECHA website

Table 22: Annex – short-chain PFAS for which the status in March 2019 is pre-registration according to the ECHA website

Substance Name	CAS No.	Status	Registration
Perfluorovaleric acid (PFPeA)	2706-90-3	Pre-registration	no entry
Undecafluorohexanoic acid (PFHxA)	307-24-4	Pre-registration	No entry
Octafluroadipic acid	336-08-3	Pre-registration	No entry
2,2,3,3,4,4,5,5-octafluorovaleric acid	376-72-7	Pre-registration	No entry
Sodium perfluorovalerate	2706-89-0	Pre-registration	No entry
Ammonium perfluorovalerate	68259-11-0	Pre-registration	No entry
Ammonium 2,2,3,3,4,4,5,5-octafluorovalerate	22715-45-3	Pre-registration	No entry
Perfluorovaleryl fluoride	375-62-2	Pre-registration	No entry
Perfluorhexanoyl fluoride	355-38-4	Pre-registration	No entry
1,1,1,2,2,3,3,4,4-nonafluoro-4-iodobutane	423-39-2	Pre-registration	No entry
Perfluoropentyl iodide	638-79-9	Pre-registration	No entry
Butane, 1-ethoxy-1,1,2,2,3,3,4,4,4-nonafluoro-	163702-05-4	Pre-registration	No entry
Diethyl octafluoroadipate	376-50-1	Pre-registration	No entry
3,3,4,4,5,5,6,6,6-nonafluorohexanol	2043-47-2	Pre-registration	No entry
1,1,1,2,2,3,3,4,4-nonafluoro-6-iodohexane	2043-55-2	Pre-registration	No entry
1,1,2,2,3,3,4,4,4-nonafluoro-N-methylbutane-1-sulfonamide (MeFBSA)	68298-12-4	Pre-registration	No entry
3,3,4,4,5,5,6,6,7,7,7-undecafluoroheptane-1-sulphonyl chloride	65702-23-0	Pre-registration	No entry
(2-carboxyethyl)dimethyl-3-[[(3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl)sulphonyl]amino]propylammonium hydroxide	61798-69-4	Pre-registration	No entry
(carboxymethyl)dimethyl-3-[methyl[(3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl)sulphonyl]amino]propylammonium hydroxide	66008-71-7	Pre-registration	No entry
(2-carboxyethyl)dimethyl-3-[methyl[(3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl)sulphonyl]amino]propylammonium hydroxide	66008-72-8	Pre-registration	No entry
3,3,4,4,5,5,6,6,6-nonafluorohexyl methacrylate	1799-84-4	Pre-registration	No entry
Thiols, C4-10, γ-ω-perfluoro	68140-18-1	Pre-registration	No entry

Substance Name	CAS No.	Status	Registration
Thiols, C4-20, γ-ω-perfluoro	68140-19-2	Pre-registration	No entry
Thiols, C6-12, γ-ω-perfluoro	68140-20-5	Pre-registration	No entry
Butanoic acid, 4-[[3-(dimethylamino)propyl]amino]-4-oxo-, 2(or 3)-[(γ-ω-perfluoro-C6-20-alkyl)thio] derivs.	68187-25-7	Pre-registration	No entry
1-Propanesulfonic acid, 2-methyl-, 2-[[1-oxo-3-[(γ-ω-perfluoro-C4-16-alkyl)thio]propyl]amino] derivs., sodium salts	68187-47-3	Pre-registration	No entry
Sulfonic acids, C6-12-alkane, perfluoro, potassium salts	68391-09-3	Pre-registration	No entry
Phosphonic acid, perfluoro-C6-12-alkyl derivs.	68412-68-0	Pre-registration	No entry
Phosphinic acid, perfluoro-C6-12-alkyl derivs.	68412-69-1	Pre-registration	No entry
1-Propanaminium, 2-hydroxy-N,N,N-trimethyl-, 3-[(γ-ω-perfluoro-C6-20-alkyl)thio] derivs., chlorides	70893-60-7	Pre-registration	No entry
Perfluorocompounds	86508-42-1	Pre-registration; deadline May 2018	No entry
Sulfonamides, C4-8-alkane, perfluoro, N-(hydroxyethyl)-N-methyl, reaction products with epichlorohydrin, adipates (esters)	91081-99-1	Pre.registration	No entry
1,4-Butanediol, 2,3-bis[(γ-ω-perfluoro-C6-20-alkyl)thio] derivs.	68187-24-6	Pre-registration	No entry
Propanamide, 3-[(γ-ω-perfluoro-C4-10-alkyl) thio] derivs	68187-42-8	Pre-registration	No entry
Alkyl iodides, C4-20, γ-ω-perfluoro	68188-12-5	Pre-registration	No entry
Sulfonamides, C4-8-alkane, perfluoro, N-ethyl-N-(hydroxyethyl), reaction products with TDI	68608-13-9	Pre-registration	No entry
1-Propanaminium, 2-hydroxy-N,N,N-trimethyl-, 3-[(γ-ω-perfluoro-C6-20-alkyl)thio] derivs., chlorides	70983-60-7	Pre-registration	No entry
Phosphonic acid, perfluoro-C6-12-alkyl derivs., aluminum salts	90481-10-0	Pre-registration	No entry
Sulfonamides, C4-8-alkane, perfluoro, N-(hydroxyethyl)-N-methyl, reaction products with epichlorohydrin, adipates (esters)	91081-99-1	Pre-registration	No entry
Sulfonyl fluorides, C1-5-alkane, ω-(ethenyloxy), perfluoro	91770-74-0	Pre-Registration	No entry
Alcohols, C4-8-tertiary, ω-(ethenyloxy), perfluoro	91770-94-4	Pre-registration	No entry
Phosphinic acid, bis(perfluoro-C6-12-alkyl) derivs., aluminum salts	93062-53-4	Pre-registration	No entry
Sulfonic acids, C6-12-alkane, perfluoro	93572-72-6	Pre-registration	No entry
Pentanoic acid, 4,4-bis[(γ-ω-perfluoro-C6-12-alkyl) thio] derivs., compds. with diethanolamine	94095-37-1	Pre-registration	No entry

Substance Name	CAS No.	Status	Registration
Butanedioic acid, sulfo-, 1,4-bis(α-ω-perfluoro-C6-12-alkyl) esters, sodium salts	94166-88-8	Pre-registration	No entry
Carbamic acid, [2-(sulfothio)ethyl]-, C-(γ-ω-perfluoro-C6-9-alkyl) esters, monosodium salts	95370-51-7	Pre-registration	No entry
Alcohols, C3-7, β-ω-perfluoro-ω-hydro, reaction products with 3a,4,7,7a-tetrahydro-1,3-isobenzofurandione	98561-40-1	Pre-registration	No entry
Alcohols, C3-7, β-ω-perfluoro-ω-hydro, reaction products with 3a,4,7,7a-tetrahydromethyl-4,7-methanoisobenzofuran-1,3-dione	98561-41-7	Pre-registratiom	No entry
Oxirane, mono[[(β-ω-perfluoro-ω-hydro-C2-4-alkyl)oxy]methyl] derivs.	98651-39-8	Pre-registration	No entry

C Appendix Catalogue of standard questions for use in information collection for the preparation of a restriction proposal under REACH

Content

C.1 Introduction

The following catalogue of standard questions can be used to set up a questionnaire to collect information in the frame of the preparation of a restriction proposal. For some areas there are optional questions included that can be used alternatively depending on the specific substance the information is intended to be collected for. A second level of differentiation was made to reflect the information provider's role in the supply chain. Following aspects are considered relevant in this regard:

- The scope of the intended restriction
  - The experiences with the two information collections in the frame of the project showed that one of the main challenges in a questionnaire is to link the information of the different areas of interest to a specific substance if the information collection is set up for a group. This is far easier, when the information collection is only made for one or very few substances.
  - In case all substances that are included in the scope of the anticipated restriction are known from the beginning, it is possible to integrate the identifiers in the questions to make the references to the substances clear. If this is not the case it might be necessary to leave this task to the information provider. This option must be seen as suboptimal as it can be a source of unprecise and incorrect information or even prevents that a potential information holder engages in the information collection.
  - In case the scope of the substances is not clearly defined, a solution can be to structure all questions in a linear way to ensure stringency within a data set. This might then lead to a situation where an information provider will need to fill in the complete questionnaire for several substances completely, which seem to be a high reduction with regard to user comfort. A preferred method would be to arrange the questions by content to enable the user to share the burden of the workload (e.g. by providing the task internally to one department that incorporates all information on substance identities, another one that can integrate information on use conditions or alternative or (socio-) economic effects of the proposed restriction.)
- The role of the information holder in the supply chain.
  REACH in many areas has its own terminology that sometimes can be perceived as technical and might be hardly understandable for data holders with less experience. So these might not understand the type of information that is really required.
  - One consequence of this consideration is the idea to take the different data holders from a starting point that is closest to their own relation in regard to the substance under discussion (e.g. the manufacturer/importer (M/I) will be rather asked about tonnages of a substance placed on the market, a downstream user (DU) rather about the substance and tonnage applied to a specific use/product).
  - To a certain degree it might be necessary to use questions that do not structure information too much to leave some flexibility for market actors to describe their situation in own words – free text. Again this might be a source of unprecise or

unnecessary information. This might increase the need to process the data manually and read through all of the statements, but this seems unavoidable.

Be aware that in a programmed version questions can be repeated. You can either move on to the next question or repeat the same question to enter additional information (e.g. for another substance, use etc.).

C.2 Survey Registration

Comments to be considered in advance:

- In most cases, surveys in the context of information collections for the preparation of a restriction proposal are open to all stakeholders. Therefore, it is important to receive some information on the information submitter, to be able to interpret the information in a wider context.
- Some information that defies an individual market actor is requested in other sections of the survey (e.g. produces products, core economic data etc.). In consequence, the section for such market actors can be very short and focussed.
- Information provided by Associations or non-government organisations (NGO) of the civil society might need more detailed description to start with to be able to interpret the provided answers.
- Obvious additional info needed are specific contact data (Name, e-mail) to be able to come back to the respondents for potential clarifications.

C.3 Individual market actors

What is your role under REACH? (multiple answers possible)

- ☐ Manufacturer/Importer of substance(s) under consideration - on its own or in mixtures
- ☐ User of substance(s) under consideration to formulate chemical products (mixtures) by direct use of a pure substance or pre-formulated mixture
- ☐ Downstream (End) user of products as process chemical that contain substance(s) under consideration or alternatives
- ☐ Downstream (End) user of products that contain substance(s) under consideration or respective alternative products where the substance remains in the final article
- ☐ Manufacturer/Importer of alternatives
- ☐ Formulator that produces alternative products (mixtures)

C.4 Associations / NGO

Please start by providing some information on your organisation

- ☐ Industry association
- ☐ Environmental NGO
- ☐ Consumer NGO
- ☐ Scientific research institution
- ☐ Member state Authority
- ☐ Other:

Please specify sector: ____________________________

Please characterise the stakeholders you represent (e.g. number of companies, national, EU-wide, international):

____

Please give some information, why your organisation is affected by / has interest in the envisaged restriction:

____

What are the main uses of the substance(s) under consideration in your sector?

____

Please indicate (as far as you can), which substance(s) under consideration are relevant for the sector (you can address different levels, e.g. chemical groups, generic descriptions or list specific Substances by names, CAS-No. etc.:

____

C.5 Substances and tonnages

Comments to be considered in advance:

- Fields highlighted in yellow can be filled in or left out if the scope of the information collection is limited to one substance only. If left blank these fields can also be filled by market actors that supply alternatives (questions are phrased in this regard).
- In certain cases it can be useful to incorporate an EC number in addition if there is the assumption that this can help clarity (sometimes the substances have undergone discussion at ECHA and EC numbers have been assigned to different substances that have formerly been assigned to one CAS-no., only.).
- Tonnage answers can be used optional, sometimes it might be more comfortable for information providers to submit ranges.
- Referencing to use descriptors might be suited especially for M/I as they are likely to be used to this from potential involvement in registrations and communication of information in the supply chain via the SDS.
- Fields in green must allow free text, because several answers can be relevant.
- Limitation of repetition of the question seems necessary for practical reasons in order to keep the database manageable. It is then possible to draft an EXCEL sheet and provide a link in the survey tool (Standard phrase could be as following "If you manufacture/use etc. more than 5 substances, you can also use the Excel-sheet (ProductList.xls) that can be downloaded here.").

C.6 Manufacturer/Importers

Which substances are manufactured/imported?

Please indicate the average manufactured tonnage (as average or as range per year) and - as far as possible - the product(s), technical function(s) and use(s) of the specific substance. Please specify all other substances under consideration in the same way.

Substance name:	
CAS-Number:	
Additional identifier:	
Tonnage average value [kg/year]:	
~ Tonnage min [kg/year]:	
~ Tonnage max [kg/year]:	
Technical function/s of the substance:	
Products the substance is used for (this can comprise substances incl. polymers, mixtures or articles - for intermediate uses please indicate the resulting substance/polymer): Please indicate tonnages for products if known in () behind each product	
Known technical function(s) of the substance:	
Known uses the substance is used in: Please indicate tonnages for uses if known in () behind each use	

When you specify your information, please use the product and article categories as defined by the ECHA Use descriptor system and the also contained list of technical functions (see link below).
https://echa.europa.eu/documents/10162/13632/information_requirements_r12_en.pdf

C.7 Downstream User/Formulator

Please specify your products containing the substance under consideration or alternative substances.

If you produce more than 5 of such products, please download this Excel-Sheet (ProductList.xls) and provide as much information on these products as possible. You can take as much time as needed to fill out the list and come back later to upload it below and leave the following lines blank.

Product/mixture Name:	
Additional product information (e.g. end product names, brand):	
Production volume of the formulated product [kg/year]:	
Product/mixture function (what is it used for)	
Substance name:	
CAS-Number:	
Additional identifier:	
Tonnage average value [kg/year]:	
~ Tonnage min [kg/year]:	
~ Tonnage max [kg/year]:	
Technical function/s of the substance:	
Products the substance is used for (this can comprise substances incl. polymers, mixtures or articles - for intermediate uses please indicate the resulting substance/polymer): Please indicate tonnages for products if known in () behind each product	
Known technical function(s) of the substance:	
Known uses the substance is used in: Please indicate tonnages for uses if known in () behind each use	

C.8 Downstream User/End user of substances and mixtures

Please indicate in which process/es you are using (alternatively which articles you are producing) the products that contain the substance/s under consideration and/or alternative substances (e.g. textile treatment, paper production, etc.), the products name/s, your approximate consumption volume of the product that contains the substance under consideration or its alternative per year and its technical function/s in your process (e.g. anti-foaming agent, surfactant, etc.).

Process/Article specification:
Additional product information (e.g. end product names, brand):
Production volume/units per year:
Please specify the product type:

When you specify your information, please use the product and article categories as defined by the ECHA Use descriptor system and the also contained list of technical functions (see link below).
https://echa.europa.eu/documents/10162/13632/information_requirements_r12_en.pdf

Product with substance under consideration or alternative substance/s?

☐ product with substance under consideration substance/s

☐ product with alternative substance/s

Please specify the substance under consideration and/or alternatives used in the product by providing the substances name/s, chemical group/s, CAS-Number/s and average concentration in the product average or range.

Substance name:	
CAS-Number:	
Additional identifier:	
Tonnage average value [kg/year]:	
~ Tonnage min [kg/year]:	
~ Tonnage max [kg/year]:	
Concentration of Substance in Chemical Product [%]	
Technical function/s of the substance:	

C.9 Article importers/assemblers

Which type of articles are placed on EU market that contain the substance under consideration or alternative substances?

Type of article:	
Product name:	
Additional identifier:	
For complex articles specify part and/or material	
For complex articles specify the weight of the part or weight of the material the substance is contained in	
Amount of articles placed on market per year (e.g. kg, pieces):	

Please specify the substance.

Substance/s name/s:	
Chemical group/s of substance/s:	
CAS-Number/s:	
Other identifier/s:	
Concentration/s in % [w/w]:	
Concentration/s range min % [w/w]:	
Concentration/s range max % [w/w]:	
Technical function/s of substance(s) :	

Please specify reference for the concentration

- ☐ concentration refers to substance in article
- ☐ concentration refers to substance in article part
- ☐ concentration refers to substance in material

C.10 Information on potential emissions along the life cycle

Comments to be considered in advance:

- Import is considered to cause no emission.
- Answer options can be reduced or extended depending on the specific situation (note: these originate from the fluorinated substances where rather low tonnages per substance were expected).
- Alternatively, it is possible to use a different question type, but pick lists seem very comfortable for information providers.
- The use of ranges makes it easier to provide information. Users can make best guesses, which are in many cases completely sufficient to determine the scope of a restriction and to understand the operational conditions. Higher precision will cause an extra workload for information holder to retrieve the data from the relevant departments internally.
- Since extensive writing should be avoided in the questionnaires, the free text fields can be limited to a maximum of characters that can be entered (e.g. 200 – 500). It is always good to put in place some placeholder questions where longer documents can be uploaded that contain additional information (with the risk that the actual questionnaire is not filled properly and the effect of structuring the data is lost).

C.11 M/DU formulators/DU End users

Please indicate how the manufacture/formulation process is performed in your organisation and number of days/batches per year.

Please choose the one that applies and provide the average number of days/batches per year in free text field:

☐ continuous production (every day) with a production volume above 10 t per day

____

☐ continuous production (every day) with a production volume above 1 t per day

____

☐ continuous production (every day) with a production volume above 100 kg per day

____

☐ continuous production (every day) with a production volume above 10 kg per day

____

☐ continuous production (every day) with a production volume above 1 kg per day

____

☐ continuous production (every day) with a production volume below 1 kg per day

____

☐ batch production with a production volume above 10 t per event

____

☐ batch production with a production volume above 1 t per event

____

☐ batch production with a production volume above 100 kg per event

____

☐ batch production with a production volume above 10 kg per event

____

☐ batch production with a production volume above 1 kg per event

____

☐ batch production volume below 1 kg per event

____

Other: ____________________________

Are there potential emissions from the manufacturing process of the substance (even in traces)? Please specify additional information below.

○ Yes

○ No

Depending on your answer, additional information on potential emissions will need to be provided.

Questions following a "Yes"

Please provide some information on potential pathways how substances can leave your manufacture process (apart from the product itself). Please choose all that apply. You have the possibility to provide additional information on the individual pathways (e.g. typical concentrations (ranges), established risk management to prevent emissions).

Please choose all that apply and provide further details:

☐ The substances are leaving the process via waste water (either from the process itself or via cleaning procedures of the establishment), please indicate concentrations of the substance(s) in the waste water if data is available:

____

☐ The substances do enter sludge in waste water treatment plants. Please indicate sludge concentration: _______________________________

☐ The substances do remain in water of waste water treatment plants. Please indicate water concentration in the outflow: _________________________

☐ The substances are contained in either liquid or solid waste, please provide additional information on waste streams and subsequent treatment (waste codes, landfill, incineration, etc.): _______________________________

☐ Some substances are emitted via off air, please indicate off air concentration [mg/m^3]:

____

Other: ____________________________

Questions following a "no"

Please include reasoning why you assume no release.

☐ No water contact (also in maintenance and cleaning).

____

☐ Substances under consideration enter hazardous waste that is subsequently incinerated.

____

☐ The substance is decomposed under the conditions of the process. Please indicate these decomposition losses below [%].

____

Other: _______________

Please describe the risk management measures that effectively retain the substance (including percentage).

Please write your answer here:

____

____

C.12 Article importer/assembler

Please indicate who is using the article as placed on the market (please select all that apply, in case of more than one user group please indicate relative share if known.):

- ☐ private consumers ____________________________
- ☐ professionals ____________________________
- ☐ industrial users ____________________________

Please give some information on the anticipated use conditions of the article:

Please choose all that apply and provide a comment:

☐ The product is subjected to cleaning with water (e.g. by washing in washing machine).

____

☐ The product is in contact with water during normal use (e.g. it is used with water, in water or outdoor in contact with rain).

____

☐ The Product is released to the environment during use (e.g. if used for surface treatment of other products, abrasion of material containing substances under discussion in this information collection).

____

☐ The product is subjected to mixed waste collection at the end of life (please specify some details).

____

☐ The product is subjected to separated waste collection with subsequent waste treatment (either due to professional collection or product specific EU-wide collection requirements – please specify some details).

____

Other: ____________________________

C.13 Information on a potential socio-economic impact of an envisaged REACH restriction and on substitution potential

Comments to be considered in advance:

- Answer options can be reduced or extended depending on the specific situation (note: these originate from the fluorinated substances where rather low tonnages per substance were expected).
- Alternatively, it is possible to use a different question type, but pick lists seem very comfortable for information providers.
- The use of ranges makes it easier to provide information. Users can make best guesses, which are in many cases completely sufficient to determine the scope of a restriction and to understand the operational conditions. Higher precision will cause an extra workload for information holder to retrieve the data from the relevant departments internally.
- Since extensive writing should be avoided in the questionnaires, the free text fields can be limited to a maximum of characters that can be entered (e.g. 200 – 500). It is always good to put in place some placeholder questions where longer documents can be uploaded that contain additional information (with the risk that the actual questionnaire is not filled properly and the effect of structuring the data is lost).

C.14 All market actors

Please provide key information on a potential socio-economic impact and the substitution potential of an envisaged REACH restriction

What is the annual turnover of your company?

- ☐ < 100.000 €
- ☐ ≥ 100.000 – 500.000 €
- ☐ ≥ 500.000 – 1. Mio €
- ☐ ≥ 1 – 10 Mio €
- ☐ ≥ 10 - 100 Mio €
- ☐ > 100 Mio €

If substantially above >> 100 Mio., please indicate a reasonable range ______________________________

How many employees does your company currently employ?

- ☐ < 50 employees
- ☐ < 250 employees
- ☐ > 250 employees

If substantially above 250 employees, please indicate a reasonable range

____

What is the relative share of your products that contain or are produced with substances under consideration on the overall turnover?

- ☐ < 5 %
- ☐ 5 - 20 %
- ☐ 20 - 50 %
- ☐ 51 - 80 %
- ☐ 81 -95 %
- ☐ > 95 %

Are you aware of any alternative products that could be used instead of your product that mediates similar properties?

- ☐ No
- ☐ Yes: ______________________________

If "Yes", please specify.

Does your portfolio already cover alternative products for comparable applications? If so, please provide information on product name(s), supplier(s):

- ☐ No
- ☐ Yes: ______________________________

If "Yes" please specify.

What is the relative share of the alternative products on the overall turnover?

- ☐ < 5 %
- ☐ 5 - 20 %
- ☐ 20 - 50 %
- ☐ 51 - 80 %
- ☐ 81 -95 %
- ☐ > 95 %

What are the differences in costs when substances under consideration are used compared to their alternatives (if there are any)?

- ☐ more than 25 % less costs than the alternative
- ☐ somewhat less costs than alternative (11-25 %)
- ☐ about the same (+/- 10 %)
- ☐ somewhat higher costs than alternative (11-25 %)
- ☐ more than 25 % higher costs than the alternative

Indicate range if substantially higher than 25% ____________________________

How would you evaluate the substitution potential for substances under consideration in your products?

Please choose each answer that applies:

	Possible but with some efforts	Substitution would lead to complete reorganisation of business	Not possible, no alternatives
economically	☐	☐	☐
technically	☐	☐	☐

Please indicate, in which areas substitution can be realised:

Please write your answer here:

____

____

How much time would you need to substitute completely to alternative substances?

- ☐ Substitution possible in less than 1 year
- ☐ Substitution possible in 1-2 years
- ☐ Substitution possible in 2-5 years
- ☐ Substitution possible in 5-10 years
- ☐ Substitution possible in more than 10 years
- ☐ Substitution not possible at all

What would be your costs to completely substitute the substance/s under consideration with alternatives?

- ☐ less than 0.1 million €
- ☐ 0.1 - 1 million €
- ☐ 1 - 10 million €
- ☐ more than 10 million €

Indicate range ____________________

C.15 General evaluation of the restriction proposal

Comments to be considered in advance:

- This section is basically used for more free text statements.
- Since it is the intention of the survey in general to get detailed information from market actors, aggregated data from associations can be submitted here.
- Since the rationale for general judgements is an individual argumentation, this is mainly a free text section with an additional option to upload documents, further evidence, position papers, etc.

C.16 All market actors/associations and NGOs

How do you evaluate the general need to continue the use of the substance/s under consideration?

Please write your answer here:

____

____

____

Do you agree with the following statements?

Please choose the appropriate response for each item:

	fully agree	agree	disagree	fully disagree
substances under consideration are a high risk for the environment	☐	☐	☐	☐
uses should be restricted, even if no alternatives are available	☐	☐	☐	☐
substances under consideration should be restricted in all consumer uses	☐	☐	☐	☐
substances under consideration should be restricted in all professional applications	☐	☐	☐	☐
substances under consideration should be allowed in very specific applications with high relevance for the society	☐	☐	☐	☐

If you agreed or disagreed to one of the statements above, you can now provide arguments for your position (you can e.g. describe applications that might qualify for such exemptions and give further reasoning):

Please write your answer here:

____

____

What are main obstacles for substitution of the substances under consideration in your sector?

Please write your answer here:

____

____

If you want to provide any other aspect in regard to the envisaged restriction proposal, you can provide these aspects in the text box below or upload documents in standard formats (word, PDF etc.) below.

Please write your answer here:

____

____

____

D Appendix Katalog mit Standardfragen zur Anwendung bei Informationserhebungen zur Erstellung von Beschränkungsvorschlägen im Rahmen von REACH

Inhalt

D.1 Einleitung

Der folgende Katalog mit Standardfragen hat das Ziel, Informationen zu erheben, um Beschränkungsverfahren im Rahmen von REACH vorzubereiten. Für einige Abschnitte wurden optionale Fragen formuliert, die, je nach dem nach welcher chemischen Substanz im Einzelfall gefragt wird, eingesetzt werden können.

Eine zweite Ebene der Differenzierung wurde eingeführt, um die Rolle der befragten Stakeholder innerhalb der Lieferkette zu berücksichtigen.

Die folgenden Aspekte sind hierfür relevant:

- Geltungsbereich des geplanten Beschränkungsverfahrens

- Im Rahmen dieses Projekts zeigte sich, dass eine größere Herausforderungen bei der Erstellung eines Fragebogens darin besteht, die verschiedenen Informationsbereiche abzugrenzen und die Informationen einzelnen Stoffen zuzuordnen, wenn nach einer Gruppe chemischer Stoffe gefragt wird. Diese Herausforderung lässt sich eindämmen, wenn die angestrebte Informationssammlung auf einen oder einige wenige Stoffe eingegrenzt wird.

- Sind alle Stoffe, auf die sich das geplante Beschränkungsverfahren beziehen soll, von vorne herein klar definiert, so ist es möglich, die Identifikatoren des entsprechenden Stoffs in die Fragen einzubeziehen. Dadurch kann ein klarer Bezug zu den einzelnen Stoffen hergestellt werden, zu denen Informationen abgefragt werden sollen. Wenn nach einer Gruppe von Stoffen gefragt wird, liegt es bei der Umfrageteilnehmerin oder dem Umfrageteilnehmer, sich auf spezifische Stoffe zu beziehen.
  Diese Vorgehensweise in einer Informationsabfrage zur Vorbereitung eines Beschränkungsverfahrens kann als weniger effizient angesehen werden, da die daraus resultierenden Ergebnisse unpräzise oder fehlerhaft übermittelt werden können. Des Weiteren kann dadurch verhindert werden, dass sich eine potentielle Umfrageteilnehmerin oder ein potentieller Umfrageteilnehmer überhaupt am Prozess der Informationssammlung beteiligt.

- In dem Fall, dass die Stoffe im Gegenstand der Informationsabfrage von vorne herein nicht klar definiert wurden, kann es hilfreich sein, alle Fragen linear zu strukturieren, um dadurch stringent die Informationszuordnung innerhalb eines Datensatzes zu gewährleisten. Dies kann allerdings dazu führen, dass eine Umfrageteilnehmerin oder ein Umfrageteilnehmer für jeden einzelnen Stoff einen Fragebogen komplett ausfüllen muss. Dies wiederum könnte große Einbußen in der Anwenderfreundlichkeit mit sich bringen.
  Eine zu präferierende Vorgehensweise wäre, die Fragen inhaltsbezogen zu gruppieren. Dadurch ermöglicht man der Anwenderin oder dem Anwender unter Umständen, den Arbeitsaufwand auf verschiedene Abteilungen aufzuteilen (z. B. auf eine Abteilung, die Informationen zu den Identifikatoren der Stoffe bereit hält und ggf. auf eine weitere Abteilung des Unternehmens, die Informationen über Anwendungsbedingungen und/oder Alternativen oder (sozio-)ökonomische Effekte des vorgeschlagenen Beschränkungsverfahrens bereitstellen kann).

► Die Rolle des Stakeholders innerhalb der Lieferkette
Die REACH-Verordnung verwendet in vielen Bereichen eine eigene Terminologie, die von weniger REACH erfahrenen Umfrageteilnehmerinnen oder Umfrageteilnehmern unter Umständen als sehr technisch wahrgenommen wird sowie ggf. sogar kaum verständlich ist. Dies kann dazu führen, dass weniger erfahrene Umfrageteilnehmerinnen oder Umfrageteilnehmer bestimmte Fragestellungen nicht umfassend verstehen und somit nicht die benötigten Informationen liefern.

- Als mögliche Konsequenz dieser Überlegungen können die verschiedenen zu befragenden Gruppen individuell dort angesprochen werden, wo die direkteste

Verbindung zum diskutierten Stoff mit dem befragten Stakeholder anzusetzen/zu identifizieren ist (so wird z. B. ein Hersteller/Importeur eher nach der Tonnage eines auf den Markt gebrachten Stoffs befragt und ein nachgeschalteter Anwender nach der eingesetzten Menge dieser Substanz in einem spezifischen Produkt/Verwendung).

- Bis zu einem bestimmten Grad kann es notwendig sein, keine Fragen zu verwenden, mit denen die Informationen zu stark vorstrukturiert werden, um ein gewisses Maß an Flexibilität aufrecht zu erhalten, damit die Marktakteure ihre Situation auch individuell und in eigenen Worten darstellen können (Freitextantworten). Dies kann, wie oben bereits erwähnt, eine Ursache für unpräzise oder überflüssige Angaben darstellen und den Bedarf für eine manuelle Auswertung der Umfrageergebnisse erhöhen (z. B. eine Prüfung und Auswertung der Freitextantworten im Einzelfall).

Es ist zu beachten, dass in programmierten Versionen von Umfragen die Fragen je nach Bedarf wiederholt werden können. Man kann so entweder zur nächsten Frage weiterspringen oder die gleiche Frage wiederholen, um zusätzliche Informationen einzugeben (z. B. für einen weiteren Stoff etc.).

D.2 Registrierungsprozess

Im Vorfeld zu berücksichtigende Aspekte:

- In den meisten Fällen sind Umfragen im Kontext der Informationssammlung zur Vorbereitung eines Beschränkungsverfahrens offen für alle Stakeholder. Um die Informationen in einem umfassenderen Kontext interpretieren zu können, ist es deswegen wichtig, einige Informationen über den befragten Stakeholder abzufragen.
- Spezifische Informationen, welche die Marktakteure direkt betreffen (z. B. produzierte Produkte, ökonomische Grunddaten etc.) werden auch in später folgenden Abschnitten der Umfrage abgefragt. Deswegen kann die Informationsabfrage zu den Marktakteuren während des Registrierungsprozesses zur Umfrage kurz und konzentriert erfolgen.
- Werden Verbände oder Nichtregierungsorganisationen (NGO´s) befragt, ist es ggf. erforderlich, umfassendere und detailliertere Informationen bereits während des Registrierungsprozesses abzufragen. Dadurch kann sichergestellt werden, dass die zur Verfügung gestellten Antworten richtig interpretiert und verstanden werden.
- Die Abfrage der Kontaktinformationen (Name und E-Mailadresse) ist zwingend notwendig, damit die Umfrageteilnehmer bei eventuellen Rückfragen oder Klärungsbedarf kontaktiert werden können.

D.3 Individuelle Marktakteure

Was ist Ihre Rolle unter REACH? (Mehrfachnennung möglich)

- ☐ Hersteller/Importeur des/der hier zu betrachtenden Stoffs/Stoffe - als solchen oder in Gemischen
- ☐ Anwender des/der hier zu betrachtenden Stoffs/Stoffe, um chemische Produkte (Gemische) zu formulieren. Diese können als reine Stoffe oder bereits in Gemischen zum Einsatz kommen.
- ☐ Nachgeschalteter (End) Anwender von Produkten, die als Prozesschemikalien zum Einsatz kommen und welche den/die hier zu betrachtenden Stoff/Stoffe oder Alternativen zu diesem/n Stoff/en enthalten
- ☐ Nachgeschalteter (End) Anwender von Produkten, die den/die hier zu betrachtende/n Stoff/e oder Alternativen zu diesem/n Stoff/en enthalten und bei denen diese Stoffe im finalen Erzeugnis verbleiben
- ☐ Hersteller/Importeur von Alternativen
- ☐ Formulierer, der alternative Produkte (Gemische) herstellt

D.4 Verbände/NGO´s

Bitte beginnen Sie mit einigen Angaben zu Ihrer Organisation

- ☐ Industrieverband

- ☐ Umwelt NGO
- ☐ Verbraucherschutz NGO
- ☐ Wissenschaftliche Forschungseinrichtung
- ☐ Mitgliedstaatenbehörde
- ☐ Andere: ____________________

Bitte Machen Sie genauere Angaben zum Sektor: ____________________

Bitte machen Sie Angaben zu den Interessensgruppen, die Sie vertreten (z. B. Anzahl Unternehmen, national, EU-weit, international):

____

Machen Sie bitte einige Angaben dazu, warum Ihre Organisation von der geplanten Beschränkung betroffen ist bzw. die Beschränkung von Interesse ist:

____

Was sind die Anwendungsfelder des/der hier zu betrachtenden Stoffs/e in Ihrem Bereich?

____

Bitte geben Sie an (soweit wie möglich), welche der hier zu betrachtenden Substanz/en in Ihrem Bereich von Relevanz sind (Sie können dabei verschiedene Detailierungsgrade nutzen, z. B. chemische Gruppen, generische Beschreibungen oder spezifische Stoffnamen, CAS-Nr. etc.).

____

D.5 Stoffe und Tonnagen

Im Vorfeld zu berücksichtigende Aspekte:

- Gelb hervorgehobene Felder können entweder vorausgefüllt oder freigelassen werden, für den Fall, dass die Umfrage auf einen einzelnen Stoff beschränkt ist. Wenn die Felder freigelassen werden, können sie auch von Marktakteuren, die Alternativen herstellen oder damit handeln, ausgefüllt werden (die Fragen sind entsprechend formuliert).
- In bestimmten Fällen kann es sinnvoll sein, zusätzlich eine EC-Nummer abzufragen. Dies kann die Zuordnung einer entsprechenden chemischen Substanz erleichtern (z. B. wenn mehreren Substanzen ehemals nur einer CAS-Nummer zugeordnet waren und dann nach einer Diskussion bei der ECHA mehrere EC-Nummern zusätzlich vergeben wurden).
- Angaben zu Tonnagen können optional verwendet werden. Manchmal kann es für die Informationsbereitstellenden komfortabler sein, Bandbreiten zu übermitteln.
- Insbesondere für Hersteller und Importeure kann es hilfreich sein, sich auf das Verwendungsdeskriptorensystem der ECHA zu beziehen, da sie unter Umständen, z. B. aufgrund einer Mitwirkung bei Registrierungen unter REACH oder über den Umgang mit Sicherheitsdatenblättern, über Erfahrungen in der Kommunikation in der Lieferkette verfügen.
- Grüne Felder müssen Freitextantworten zulassen, da in diesen Fällen mehrere Antworten relevant sein können.
- Eine Limitierung von Fragenwiederholungen ist notwendig, um die Gesamtdatenmenge handhabbar zu halten. In solchen Fällen der Limitierung bietet es sich an, die Dateneingabe über ein Excel-Datenblatt anzubieten und mittels eines Links in der Umfrage zur Verfügung zu stellen. Eine mögliche Standardformulierung kann lauten: „Wenn Sie mehr als 5 Stoffe herstellen, können Sie die Angaben auch mittels dieses Excel-Arbeitsblatts übermitteln (SubstancesList.xls).“

D.6 Hersteller/Importeur

Welche Stoffe werden hergestellt/importiert

Bitte geben Sie die durchschnittlich hergestellte Tonnage ein (als Durchschnittswert oder als Bandbreite pro Jahr) und - soweit es Ihnen möglich ist - die technische(n) Funktion(en) und Verwendung(en) des Stoffes. Bitte spezifizieren Sie alle weiteren Stoffe, die Sie herstellen.

Stoffname:	
CAS-Nummer:	
Weitere Identifikatoren:	
Durchschnittliche Tonnage [kg/Jahr]:	
~ Tonnage min [kg/Jahr]:	
~ Tonnage max [kg/year]:	
Technische Funktion(en) des Stoffs:	
Produkte bei denen der Stoff zur Anwendung kommt (kann Stoffe, inkl. Polymere, Gemische oder auch Erzeugnisse, umfassen - bei Anwendung als Zwischenprodukt nennen Sie bitte den resultierenden Stoff/das Polymer): Wenn bekannt, geben Sie bitte die Tonnage der Produkte in Klammern hinter den Produkten an.	
Bekannte technische Funktion(en) des Stoffes:	
Bekannte Verwendungen in denen der Stoff zur Anwendung kommt:	

Um Ihre Angaben zu spezifizieren, orientieren Sie sich bei Ihren Angaben an den Produkt- und Erzeugniskategorien des ECHA Verwendungsdeskriptorensystems sowie der dort enthaltenen Auflistung der technischen Funktionen.
https://echa.europa.eu/documents/10162/13632/information_requirements_r12_en.pdf

D.7 Nachgeschaltete Anwender/Formulierer

Bitte spezifizieren Sie die Produkte, welche den hier zu betrachtenden Stoff oder Alternativen für diesen Stoff enthalten.

Wenn Sie mehr als 5 Produkte herstellen, können Sie die Angaben auch mittels dieses Excel-Arbeitsblatts übermitteln (ProductList.xls). Sie können sich dabei so viel Zeit lassen, wie Sie benötigen, um die Liste zu vervollständigen und dann später hierher zurückkehren und die Liste unterhalb des Abschnitts hochladen. Wenn Sie das Excel-Arbeitsblatt verwenden, brauchen Sie in den folgenden Zeilen keine Eintragungen vornehmen.

Name des Produkts/Gemisches:	
zusätzliche Informationen zum Produkt (z. B. Markennamen):	
Produktionsvolumen des formulierten Produkts [kg/Jahr]:	
Produkt-/Gemischfunktion (was ist die Vwerwendung)	
Stoffname:	
CAS-Nummer:	
Weitere Identifikatoren:	
Durchschnittliche Tonnage [kg/Jahr]:	
~ Tonnage min [kg/Jahr]:	
~ Tonnage max [kg/Jahr]:	
Technische Funktion(en) des Stoffs:	
Produkte bei denen der Stoff zur Anwendung kommt (kann Stoffe, inkl. Polymere, Gemische oder auch Erzeugnisse, umfassen - bei Anwendung als Zwischenprodukt nennen Sie bitte den resultierenden Stoff/das Polymer): Wenn bekannt, geben Sie bitte die Tonnage der Produkte in Klammern () hinter den Produkten an.	
Bekannte technische Funktion(en) des Stoffs	
Bekannte Verwendungen in denen der Stoff zur Anwendung kommt: Wenn bekannt, geben Sie bitte die Tonnage der bekannten Verwendungen in Klammern () hinter den Anwendungen an.	

D.8 Nachgeschalteter Anwender/Endanwender von Stoffen und Gemischen

Bitte geben Sie an, in welchem/welchen Prozess(en) Sie Produkte verwenden(alternativ: welche Erzeugnisse Sie produzieren), welche die zu betrachtenden Stoffe oder deren Alternativen enthalten (z. B. Textilbehandlung, Papierherstellung etc.) sowie die Namen der Produkte, die ungefähre Nutzungsmenge des Produkts mit den zu betrachtenden Stoffen oder den Alternativen pro Jahr und die technische(n) Funktion(en) (z. B. Antischaummittel, Beschichtungshilfsmittel etc.) in dem Prozess.

Prozesstyp/Erzeugnis:
Zusätzliche Produktinformationen (z. B. Name des Endprodukts, Markenname):
Produktionsvolumen/Einheiten pro Jahr:
Bitte spezifizieren Sie den Produkttypen:

Um Ihre Angaben zu spezifizieren, orientieren Sie sich bei Ihren Angaben an den Produkt und Erzeugniskategorien des ECHA Verwendungsdeskriptorensystems sowie der dort enthaltenen Auflistung der technischen Funktionen.
https://echa.europa.eu/documents/10162/13632/information_requirements_r12_en.pdf

Produkt, welches den zu betrachtenden Stoff oder eine Alternative enthält?

☐ Produkt, welches den zu betrachtenden Stoff enthält

☐ Produkt, welches Alternativen zu dem zu betrachtenden Stoff enthält

Bitte spezifizieren Sie den/die hier zu betrachtende/n Stoff/e und/oder dessen/deren Alternative/n, welche/r in dem Produkt angewendet werden und nennen Sie dabei den/die Stoffnamen, die chemische/n Gruppe/n, die CAS-Nummer/n und die durchschnittliche Konzentration im Produkt (im Durchschnitt oder unter Angabe einer Bandbreite).

Stoffname:	
CAS-Nummer:	
Zusätzliche Identifikatoren:	
Durchschnittliche Tonnage [kg/Jahr]:	
~ Tonnage min [kg/Jahr]:	
~ Tonnage max [kg/Jahr]:	
Konzentration des Stoffes im chemischen Produkt [%]:	
Technische Funktion(en) des Stoffs:	

D.9 Importeure /Produzent von Erzeugnissen (aus Erzeugnissen)

Welche Erzeugnisse, die den/die hier zu betrachtenden Stoff/e oder Alternativen enthalten, werden in der EU in Verkehr gebracht?

Erzeugnistyp:	
Produktname:	
Weitere Namen:	
Für komplexe Erzeugnisse spezifizieren Sie bitte die Teile/das Material das den/die Soff/e enthält	
Für komplexe Erzeugnisse geben Sie bitte das Gewicht des Bauteils/Materials, welches den/die Stoff/e enthält, an	
Anzahl der auf den Markt gebrachten Einheiten (bitte spezifizieren Sie eine Einheit, z. B. kg, Stück etc.):	

Angaben zum Stoff:

Stoffname(n):	
Chemische Gruppenzugehörigkeit:	
CAS-Nummer/n:	
Andere Identifikatoren:	
Konzentration/en % [w/w]:	
Konzentrationsbereich min % [w/w]:	
Konzentrationsbereich max % [w/w]:	
Technische Funktion(en) des/der Stoffe/s:	

Bitte geben Sie die Referenzgrößen zu den Konzentrationen an

- ☐ Konzentration bezieht sich auf den/die Stoff/e im Erzeugnis
- ☐ Konzentration bezieht sich auf den/die Stoff/e in einem Teil des Erzeugnisses
- ☐ Konzentration bezieht sich auf den/die Stoff/e im Material

D.10 Informationen über potentielle Emissionen entlang des Lebenszyklus

Im Vorfeld zu berücksichtigende Aspekte:

- Es wird davon ausgegangen, dass der Import keine Emissionen verursacht.
- Je nach gegebener Situation können die Antwortoptionen reduziert oder erweitert werden. (Hinweis: Diese Vorgehensweise stammt aus der Umfrage zu den fluorierten Chemikalien, hier wurden z. B. eher geringe Tonnagen pro chemischem Stoff erwartet.)
- Es ist auch möglich, alternative Fragetypen anzuwenden. Allerdings stellen Auswahllisten eine anwenderfreundliche Lösung dar.
- Die Abfrage von Bereichen macht es ggf. leichter für die Umfrageteilnehmerin oder den Umfrageteilnehmer, Angaben zu machen. Es können Schätzungen abgegeben werden, welche in den meisten Fällen für die Ermittlung der notwendigen Informationen in Hinblick auf ein geplantes Beschränkungsverfahren oder für ein Verständnis über die Anwendungsfelder der eingesetzten chemischen Stoffe völlig hinreichend sind. Ein größerer Detailgrad in der Abfrage von Informationen zu den produzierten Mengen kann zu einem erheblichen Mehraufwand für die Umfrageteilnehmerin oder den Umfrageteilnehmer führen, da hierfür ggf. in den entsprechenden Abteilungen nachgefragt werden müsste.
- Zu lange Texte in Freitextfeldern sollten aufgrund des Mehraufwands in der Auswertung vermieden werden. Dies kann erreicht werden, indem man die mögliche Zeichenanzahl in Freitextfeldern limitiert (z. B. auf 200-500 Zeichen). An diesen Stellen ist es zumeist sinnvoll, Platzhalterfragen einzusetzen, die einen Upload zusätzlicher Dokumente ermöglichen. (Dies birgt allerdings das Risiko, dass der eigentliche Fragebogen ggf. nicht so sorgfältig ausgefüllt wird, wodurch die Strukturierung der Daten verloren geht.).

D.11 Hersteller/Nachgeschaltete Anwender Formulierer / Endanwender

Bitte beschreiben Sie den Herstellungs-/Formulierungsprozess in Ihrer Organisation näher und geben Sie bitte die Anzahl der Tage/Chargen an.

Bitte wählen Sie die zutreffenden Punkte aus und übermitteln Sie die durchschnittliche Anzahl der Tage/Chargen pro Jahr in einem Freitextfeld:

☐ kontinuierliche Produktion, Produktionsvolumen oberhalb von 10 t/Tag

____

☐ kontinuierliche Produktion, Produktionsvolumen oberhalb von 1 t/Tag

____

☐ kontinuierliche Produktion, Produktionsvolumen oberhalb von 100 kg/Tag

____

☐ kontinuierliche Produktion, Produktionsvolumen oberhalb von 10 kg/Tag

____

☐ kontinuierliche Produktion, Produktionsvolumen oberhalb von 1 kg/Tag

____

☐ kontinuierliche Produktion, Produktionsvolumen unterhalb von 1 kg/Tag

____

☐ Chargenproduktion, Produktionsvolumen oberhalb von 10 t/Kampagne

____

☐ Chargenproduktion, Produktionsvolumen oberhalb von 1 t/Kampagne

____

☐ Chargenproduktion, Produktionsvolumen oberhalb von 100 kg/Kampagne

____

☐ Chargenproduktion, Produktionsvolumen oberhalb von 10 kg/Kampagne

____

☐ Chargenproduktion, Produktionsvolumen oberhalb von 1 kg/Kampagne

____

☐ Chargenproduktion, Produktionsvolumen unterhalb von 1 kg/Kampagne

____

Sonstiges:: ______________________

Besteht die Möglichkeit, dass der/die hier zu betrachtende/n Stoff/e aus dem Prozess emittiert werden (auch in Spuren)?

○ Ja

○ Nein

Abhängig von Ihrer Antwort müssen weitere Informationen zu potentiellen Emissionen übermittelt werden!

Fragen, die einer Beantwortung der oben stehenden Frage mit „Ja" folgen:

Bitte machen Sie einige Angaben zu den potentiellen Pfaden, auf denen Stoffe den Herstellungsprozess verlassen könnten (außer über das Produkt selbst). Bitte wählen Sie alle zutreffenden Punkte aus. Sie haben die Möglichkeit, zusätzliche Informationen zu den einzelnen Pfaden zu übermitteln (z. B. typische Konzentration (Bereiche), etabliertes Risikomanagement).

Bitte wählen Sie alle zutreffenden Punkte aus und machen sie weitere Angaben zu Details:

☐ Die Stoffe verlassen den Prozess über das Abwasser (entweder über das Prozessabwasser selber oder über Reinigungsmaßnahmen der Anlage). Machen Sie bitte Angaben zur Konzentration der Stoffe im Abwasser sofern dazu Daten vorliegen.

____

☐ Die Stoffe gehen in Klärschlämme über, wenn Abwässer in Kläranlagen behandelt werden. Bitte geben Sie die Konzentrationen im Klärschlamm an: ______________________________

☐ Die Stoffe verbleiben im Wasser, wenn Abwässer in Kläranlagen behandelt werden. Bitte geben Sie die Konzentrationen im Wasser nach der Behandlung im Kläranlagenausfluss an:

____

☐ Einige der Stoffe sind in flüssigen oder festen Abfällen enthalten. Bitte machen Sie zusätzliche Angaben zu den Abfallströmen und der anschließenden Behandlung (z. B. Abfallschlüssel, Deponieverbringung, Verbrennung, etc.): ______________________________

☐ Einige Stoffe werden über die Abluft emittiert. Bitte geben Sie Ihre Konzentration [mg/m^3] in der Abluft an: ______________________________

Sonstiges: ____________________________

Fragen, die der Beantwortung der oben stehenden Frage mit einem „nein“ folgen:

Bitte geben Sie eine Begründung an, warum Sie eine Freisetzung des Stoffes ausschließen.

☐ kein Wasserkontakt (auch während Wartung und Reinigung)

____

☐ Die hier zu betrachtenden Stoffe werden zu gefährlichem Abfall, der anschließend verbrannt wird

____

☐ Die hier zu betrachtenden Stoffe werden während des Prozesses zersetzt. Bitte machen Sie Angaben zum Grad der Zersetzung.

____

Sonstiges: ______________________

Bitte beschreiben Sie das etablierte Risikomanagement, welches geeignet ist, die Stoffe effektiv zurückzuhalten (inklusive einer Prozentangabe).

Bitte geben Sie Ihre Antwort hier ein:

____

____

D.12 Importeure /Assembler von Erzeugnissen (aus Erzeugnissen)

Bitte machen Sie Angaben darüber, wer das Erzeugnis, welches in Verkehr gebracht wird, verwendet (bitte wählen Sie alles Zutreffende aus, falls mehrere Nutzergruppen zutreffen, machen Sie bitte Angaben über eine ungefähre Verteilung zwischen den Gruppen, wenn bekannt):

☐ private Verbraucher ____________________________

☐ professionelle Nutzer____________________________

☐ industrielle Nutzer ____________________________

Bitte machen Sie einige Angaben zu vorhersehbaren Anwendungsbedingungen des Erzeugnisses:

Bitte wählen Sie alle zutreffenden Punkte aus und schreiben Sie einen Kommentar dazu:

☐ Das Produkt wird der Reinigung mit Wasser unterzogen (z. B. in der Waschmaschine).

____

☐ Das Produkt ist während der Nutzung in Kontakt mit Wasser (z. B. da es mit Wasser genutzt wird, im Wasser genutzt wird oder bei Außenanwendung durch Regen Wasserkontakt besteht).

____

☐ Das Produkt wird während der Nutzung in die Umgebung abgegeben (z. B. zur Oberflächenbehandlung anderer Produkte, Abrieb des Materials, welches die hier zu betrachtenden Stoffe enthält).

____

☐ Das Produkt wird am Ende der Nutzung über haushaltsähnlichen Abfallstrom entsorgt (bitte, machen Sie dazu nähere Angaben).

____

☐ Das Produkt wird einer separierten Abfallsammlung mit anschließender Behandlung unterzogen (entweder aufgrund einer professionellen Sammlung oder auf Basis einer EU-weit vorgeschriebenen produktspezifischen Sammlung – bitte machen Sie dazu nähere Angaben).

____

Sonstiges: ____________________________

D.13 Informationen über potentielle sozio-ökonomische Effekte einer geplanten REACH Beschränkung und zum Substitutionspotenzial

Im Vorfeld zu beachtende Aspekte:

- Je nach gegebener Situation können die Antwortoptionen reduziert oder erweitert werden. (Hinweis: Diese Vorgehensweise stammt aus der Umfrage zu den fluorierten Chemikalien, hier wurden z. B. eher geringe Tonnagen pro chemischem Stoff erwartet.)
- Es ist auch möglich, alternative Fragetypen anzuwenden. Allerdings stellen Auswahllisten eine anwenderfreundliche Lösung dar.
- Die Abfrage von Bereichen macht es ggf. leichter für die Umfrageteilnehmerin oder den Umfrageteilnehmer, Angaben zu machen. Es können Schätzungen abgegeben werden, welche in den meisten Fällen für die Ermittlung der notwendigen Informationen in Hinblick auf ein geplantes Beschränkungsverfahren oder für ein Verständnis über die Anwendungsfelder der eingesetzten chemischen Stoffe völlig hinreichend sind. Ein größerer Detailgrad in der Abfrage von Informationen zu den produzierten Mengen kann zu einem erheblichen Mehraufwand für die Umfrageteilnehmerin oder den Umfrageteilnehmer führen, da hierfür ggf. in den entsprechenden Abteilungen nachgefragt werden müsste.
- Zu lange Texte in Freitextfeldern sollten aufgrund des Mehraufwands in der Auswertung vermieden werden. Dies kann erreicht werden, indem man die mögliche Zeichenanzahl in Freitextfeldern limitiert (z. B. auf 200-500 Zeichen). An diesen Stellen ist es zumeist sinnvoll, Platzhalterfragen einzusetzen, die einen Upload zusätzlicher Dokumente ermöglichen. (Dies birgt allerdings das Risiko, dass der eigentliche Fragebogen ggf. nicht so sorgfältig ausgefüllt wird, wodurch die Strukturierung der Daten verloren geht.).

D.14 Alle Marktakteure

Bitte übermitteln Sie einige Basisinformationen über potentielle sozio-ökonomische Auswirkungen sowie das Substitutionspotential eines angestrebten Beschränkungsverfahrens unter REACH.

Wie hoch ist der jährliche Umsatz Ihres Unternehmens?

- ☐ < 100.000 €
- ☐ ≥ 100.000 – 500.000 €
- ☐ ≥ 500.000 – 1. Mio €
- ☐ ≥ 1 – 10 Mio €
- ☐ ≥ 10 - 100 Mio €
- ☐ > 100 Mio €

Sollte der Umsatz >> 100 Mio übersteigen, geben Sie an dieser Stelle eine sinnvolle Größenordnung an: ____________________________

Wie viele Mitarbeiterinnen und Mitarbeiter beschäftigt Ihr Unternehmen?

- ☐ < 50 Angestellte
- ☐ < 250 Angestellte
- ☐ ≥ 250 Angestellte

Wenn Ihr Unternehmen deutlich mehr als 250 Angestellte beschäftigt, geben Sie an dieser Stelle eine sinnvolle Größenordnung an:

____

Wie hoch ist der relative Anteil Ihrer Produkte, die mit dem/den hier zu betrachtenden Stoff/en hergestellt wurden oder diese/n Stoff/e enthalten am Gesamtumsatz?

- ☐ < 5 %
- ☐ 5 - 20 %
- ☐ 20 - 50 %
- ☐ 51 - 80 %
- ☐ 81 -95 %
- ☐ > 95 %

Kennen Sie alternative Produkte mit ähnlichen Eigenschaften, die anstelle Ihres Produktes zum Einsatz kommen können und die ähnliche Funktionalitäten vermitteln?

- ☐ Nein
- ☐ Ja: ____________________________

  Wenn "Ja", machen Sie bitte detaillierte Angaben.

Gibt es in Ihrem Produktportfolio bereits alternative Produkte für vergleichbare Anwendungsbereiche? Wenn ja, geben Sie bitte den/die Produktbezeichnung/en und Lieferant(en) an:

- ☐ Nein
- ☐ Ja: ____________________

Wenn "Ja", machen Sie bitte detaillierte Angaben.

Wie hoch ist der relative Anteil alternativer Produkte am Gesamtumsatz?

- ☐ < 5 %
- ☐ 5 - 20 %
- ☐ 20 - 50 %
- ☐ 51 - 80 %
- ☐ 81 -95 %
- ☐ > 95 %

Wie hoch sind die Unterschiede in den Produktionskosten, wenn die hier zu betrachtenden Stoffe zum Einsatz kommen im Vergleich zu den Alternativen (sofern diese vorhanden sind)?

- ☐ mehr als 25 % geringere Kosten als bei Verwendung der Alternative
- ☐ etwas geringere Kosten als bei Verwendung der Alternative (11-25 %)
- ☐ etwa gleich (+/- 10 %)
- ☐ etwas höhere Kosten als bei Verwendung der Alternative (11-25 %)
- ☐ mehr als 25 % höhere Kosten als bei Verwendung der Alternative

Wenn wesentlich höher, geben Sie an dieser Stelle bitte einen Bereich an:

Wie bewerten Sie das Substitutionspotential der hier zu betrachtenden Stoffe in Ihren Produkten?

Bitte kreuzen sie alle zutreffenden Antworten an.

	Möglich, aber mit einigem Aufwand verbunden	Substitution würde zu einer kompletten Reorganisation der Geschäftsaktivitäten führen	Nicht möglich, da keine Alternativen
Wirtschaftlich	☐	☐	☐
technisch	☐	☐	☐

Bitte machen Sie Angaben zu Bereichen, in denen eine Substitution realisierbar ist:

Bitte geben Sie Ihre Antwort hier ein:

In welchem Zeitraum könnte eine komplette Substitution der hier zu betrachtenden Stoffe bei Ihnen vollzogen werden?

- ☐ Substitution möglich in weniger als einem Jahr
- ☐ Substitution möglich in 1-2 Jahren
- ☐ Substitution möglich in 2-5 Jahren
- ☐ Substitution möglich in 5-10 Jahren
- ☐ Substitution möglich in mehr als 10 Jahren
- ☐ Substitution nicht möglich

Was würde eine komplette Substitution der Stoffe durch Alternativen kosten?

- ☐ weniger als 0,1 Millionen €
- ☐ 0,1 - 1 Million €
- ☐ 1 - 10 Million €
- ☐ mehr als 10 Millionen €

Schätzen Sie die Größenordnung: ______________________________

D.15 Allgemeine Bewertung des Beschränkungsvorschlags

Im Vorfeld zu beachtende Aspekte:

- In diesem Abschnitt kommen grundsätzlich mehr Freitextfragen zum Einsatz.
- Da eine Umfrage zur Vorbereitung eines Beschränkungsverfahrens darauf abzielt, möglichst detaillierte Informationen von den Marktakteuren zu erhalten, können hier aggregierte Daten von Verbänden übermittelt werden.
- Da Begründungen für eine allgemeine Bewertung im Wesentlichen auf einer individuellen Argumentation basieren, ist dies zu großen Teilen ein Freitextabschnitt, mit der zusätzlichen Möglichkeit, Dokumente, weitere Belege, Positionspapiere etc. hochzuladen.

D.16 Alle Marktakteure/Verbände und NGO´s

Wie bewerten Sie die grundsätzliche Notwendigkeit, die Verwendung der hier zu betrachtenden Stoffe fortzuführen?

Bitte geben Sie Ihre Antwort hier ein:

____

____

____

Stimmen Sie den folgenden Aussagen zu?

Bitte wählen Sie die zutreffende Antwort für jeden Punkt aus:

	stimme voll und ganz zu	**stimme zu**	**stimme nicht zu**	**stimme absolut nicht zu**
Die hier zu betrachtenden Stoffe stellen ein hohes Risiko für die Umwelt dar.	☐	☐	☐	☐
Verwendungen sollten beschränkt werden, auch wenn keine Alternativen bekannt sind.	☐	☐	☐	☐
Die hier zu betrachtenden Stoffe sollten in allen Verbraucheranwendungen beschränkt werden.	☐	☐	☐	☐
Die hier zu betrachtenden Stoffe sollten in allen gewerblichen Anwendungen beschränkt werden.	☐	☐	☐	☐

Die hier zu betrachtenden Stoffe sollten in bestimmten Verwendungen mit hoher Relevanz für die Gesellschaft erlaubt bleiben.	☐	☐	☐	☐

Sollten Sie einem dieser Punkte zugestimmt oder nicht zugestimmt haben, können sie nun Ihre Argumente für Ihre Position darlegen (Sie können z. B. Anwendungen aufführen, die ggf. für eine Ausnahme geeignet sein könnten und weitere Argumente dafür anführen).

Bitte geben Sie Ihre Antwort hier ein:

____

____

Was sind die Haupthindernisse für eine Substitution von den hier zu betrachtenden Stoffen in Ihrem Bereich?

Bitte geben Sie Ihre Antwort hier ein:

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Sollten Sie weitere Aspekte zu dem geplanten Beschränkungsvorschlag beitragen wollen, können Sie diese in das nachfolgende Textfeld eingeben oder ein Dokument in einem Standardformat hochladen (Word, PDF etc.).

Bitte geben Sie Ihre Antwort hier ein:

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