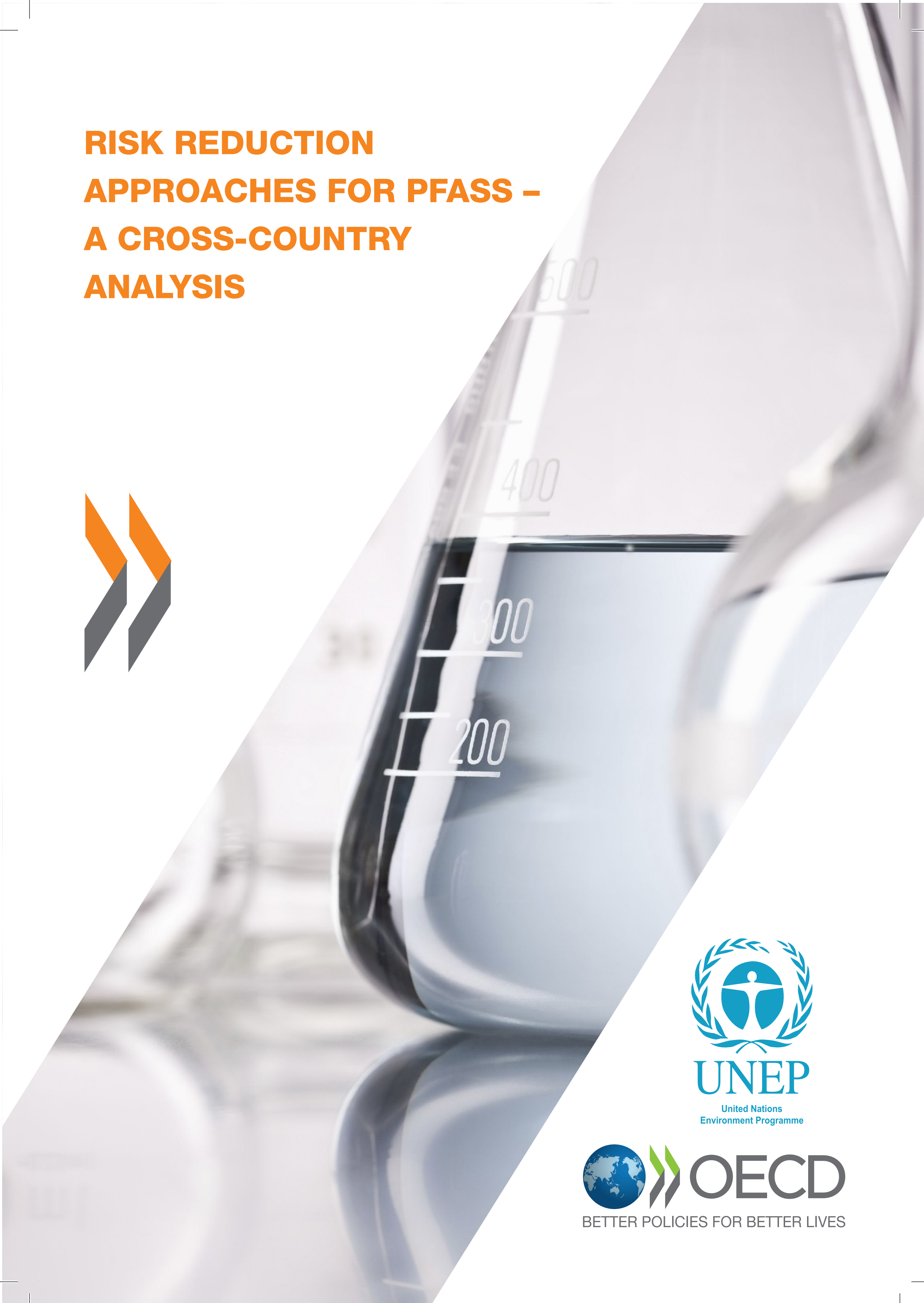
RISK REDUCTION APPROACHES FOR PFASS – A CROSS-COUNTRY ANALYSIS



UNEP
United Nations
Environment Programme

OECD
BETTER POLICIES FOR BETTER LIVES

OECD Environment, Health and Safety Publications
Series on Risk Management
No. 29

RISK REDUCTION APPROACHES FOR PFASS – A CROSS-COUNTRY ANALYSIS

This publication is available electronically, at no charge.

For this and many other Environment,
Health and Safety publications, consult the OECD's
World Wide Web site (www.oecd.org/chemicalsafety/)

or contact:

OECD Environment Directorate,
Environment, Health and Safety Division
2 rue André-Pascal
75775 Paris Cedex 16
France

Fax: (33-1) 44 30 61 80

E-mail: ehscont@oecd.org

IOMC

INTER-ORGANIZATION PROGRAMME FOR THE SOUND MANAGEMENT OF CHEMICALS

A cooperative agreement among **FAO, ILO, UNDP, UNEP, UNIDO, UNITAR, WHO, World Bank and OECD**

Environment Directorate
ORGANISATION FOR ECONOMIC COOPERATION AND DEVELOPMENT
Paris 2015

Also published in the Series on Risk Management:

No. 1: Lead. Background and National Experience with Reducing Risk (1993)

No. 2: Methylene Chloride. Background and National Experience with Reducing Risk (1994)

No. 3: Selected Brominated Flame Retardants. Background and National Experience with Reducing Risk (1994)

No. 4: Mercury. Background and National Experience with Reducing Risk (1994)

No. 5: Cadmium. Background and National Experience with Reducing Risk (1994)

No. 6: Methylene Chloride Information Exchange Programme: Survey Results (1996)

No. 7: Proceedings of the OECD Workshop on Non-Regulatory Initiatives for Chemical Risk Management (1997)

No. 8: Proceedings of the OECD Workshop on the Effective Recycling of Nickel-Cadmium Batteries, Lyon, France, 23-25 September 1997 (1999)

No. 9: Proceedings of the OECD Workshop on the Integration of Socio-Economic Analysis in Chemical Risk Management Decision-making, London, 7-9 January, 1998 (1999)

No. 10: Proceedings of the OECD Workshop on Sustainable Chemistry, Venice, 15-17 October 1998 (1999)

No. 11: Guidance for Conducting Retrospective Studies on Socio-Economic Analysis (1999)

No. 12: Lead Risk Management Activities in OECD Countries from 1993 to 1998 (2000)

No. 13: Framework for Integrating Socio-Economic Analysis in Chemical Risk Management Decision Making (2000)

No.14: Technical Guidance Document on the Use of Socio-Economic Analysis in Chemical Risk Management Decision Making (2002)

No. 15: Need for Research and Development Programmes in Sustainable Chemistry (2002)

No. 16: OECD Guidance Document on Risk Communication for Chemical Risk Management (2002)

No. 17: Strategies in the Chemicals Industry and Related Areas; Vienna, Austria, 13-14 November 2003,Part I and Part II: Summary and Conclusions (2004)

No.18: Workshop on Exchanging Information Across a Chemical Product Chain, Stockholm, Sweden, 15-16 June 2004 (2004)

No.19: Results of Survey on Production and Use of PFOs, PFAs and PFOA, related Substances and Products/ Mixtures containing these Substances (2005)

No. 20: Workshop Report on Consideration of Chemical Safety in Green Procurement, Seoul, Korea, 8-10 November 2005 (2006)

No. 21: Preliminary Lists of PFOS, PFAS, PFOA, PFCA, their related Compounds and Chemicals that may degrade to PFCA (2006)

No. 22: Results of the 2006 Survey on Production and Use of PFOS, PFAS, PFOA, PFCA, and their Related Substances and Products/Mixtures Containing these Substances (2006)

No.23: Report of an OECD Workshop on Perfluorocarboxylic Acids (PFCAs) and Precursors (2006)

No.24: PFCs: Outcome of the 2009 Survey – Survey on the Production, Use and Release of PFOS, PFAS, PFOA, PFCA, their related Substances and Products/Mixtures containing these Substances. (2011)

No.25: Sustainable Chemistry: Evidence on Innovation from Patent Data. (2011)

No.26: Current Landscape of Alternatives Assessment Practice: A Meta-Review. (2013)

No.27: Synthesis Paper on Per- And Polyfluorinated Chemicals (Pfcs). (2013)

No. 28: Preliminary Analysis of Policy Drivers Influencing Decision-Making in Chemicals Management. (2015)

Other OECD Environment, Health and Safety Publications related to Risk Management:

OECD Proceedings: Sources of Cadmium in the Environment (1996)

OECD Proceedings: Fertilizers as a Source of Cadmium (1996)

TABLE OF CONTENTS

ABOUT THE OECD

The Organisation for Economic Co-operation and Development (OECD) is an intergovernmental organisation in which representatives of 34 industrialised countries in North and South America, Europe and the Asia and Pacific region, as well as the European Commission, meet to co-ordinate and harmonise policies, discuss issues of mutual concern, and work together to respond to international problems. Most of the OECD's work is carried out by more than 200 specialised committees and working groups composed of member country delegates. Observers from several countries with special status at the OECD, and from interested international organisations, attend many of the OECD's workshops and other meetings. Committees and working groups are served by the OECD Secretariat, located in Paris, France, which is organised into directorates and divisions.

The Environment, Health and Safety Division publishes free-of-charge documents in 11 different series: **Testing and Assessment; Good Laboratory Practice and Compliance Monitoring; Pesticides; Biocides; Risk Management; Harmonisation of Regulatory Oversight in Biotechnology; Safety of Novel Foods and Feeds; Chemical Accidents; Pollutant Release and Transfer Registers; Emission Scenario Documents; and Safety of Manufactured Nanomaterials.** More information about the Environment, Health and Safety Programme and EHS publications is available on the OECD's World Wide Web site (www.oecd.org/chemicalsafety/).

This publication was developed in the IOMC context. The contents do not necessarily reflect the views or stated policies of individual IOMC Participating Organisations.

The Inter-Organisation Programme for the Sound Management of Chemicals (IOMC) was established in 1995 following recommendations made by the 1992 UN Conference on Environment and Development to strengthen co-operation and increase international co-ordination in the field of chemical safety. The Participating Organisations are FAO, ILO, UNDP, UNEP, UNIDO, UNITAR, WHO, World Bank and OECD. The purpose of the IOMC is to promote co-ordination of the policies and activities pursued by the Participating Organisations, jointly or separately, to achieve the sound management of chemicals in relation to human health and the environment.

FOREWORD

The document was prepared by the OECD/UNEP Global PFC Group, established to respond to the International Conference on Chemicals Management (ICCM 2) 2009 Resolution II/5 regarding PFCs under the framework of the Strategic Approach to International Chemicals Management (SAICM). The report aims to inform discussions on progress with respect to the ICCM Resolution at ICCM 4 in September 2015.

LIST OF ACRONYMS

AFIRM	Apparel & Footwear International RSL Management Group
AFFF	Aqueous filmforming foams
APFO	Ammonium perfluorooctanoate
BEP	Best environmental practice
CA	Swedish Chemical Agency
CDC	US Centers for Disease Control and Prevention
CiP	Chemicals in product
COHIBA	Control of Hazardous Substances in the Baltic Sea Region
CSCL	Chemical Substances Control Law
EC	European Commission
ECA	Enforceable consent agreement
ECHA	European Chemicals Agency
EMC	Environmental Medicine Collaboration Center
ETFE	Ethylene tetrafluoroethylene copolymer
EU	European Union
FOSA	Sulfonamide perfluorooctane
HELCOM	Baltic Marine Environment Protection Commission
ICCM	International Conference on Chemicals Management
ICNA Act	Industrial Chemicals (Notification and Assessment) Act of 1989
LCD	Liquid crystal display
LC-PFAS	Long-chain per- and polyfluoroalkyl substance
MEP	Ministry of Environmental Protection of the People's Republic of China
MRSL	Manufacturing Restricted Substances List
NGO	Non-governmental organisation
NICNAS	National Industrial Chemicals Notification Scheme
OECD	Organisation for Economic Co-operation and Development
PASF	Perfluoroalkane sulfonyl fluoride
PBT	Persistent, Bioaccumulative, and Toxic
PFAA	Perfluoroalkyl acid
PFAS	Per- and polyfluoroalkyl substance
PFBA	Perfluorobutanoic acid
PFBS	Perfluorobutane sulfonic acid

PFCs	Per- and poly-fluorinated chemicals; perfluorocarbons
PFCA	Perfluoroalkyl carboxylic acid
PFHpA	Perfluoroheptanoic acid
PFHxA	Perfluorohexanoic acid
PFHxS	Perfluorohexane sulfonic acid
PFDA	Perfluorodecanoic acid
PFNA	Perfluorononanoic acid
PFO	Perfluorooctanoate
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctane sulfonic acid
PFOSA	Perfluorooctane sulfonamide
PFOSF	Perfluorooctane sulfonyl fluoride
PFPeA	Perfluoro-n-pentanoic acid
PFSA	Perfluoroalkyl sulfonic acid
POP	Persistent organic pollutant
POSF	Perfluorooctane sulfonyl fluoride
PTFE	Polytetrafluoroethlyene
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
RSL	Restricted substances guidance
SAICM	Strategic Approach to International Chemicals Management
SC-PFAS	Short-chain per- and polyfluoroalkyl substance
SNUR	Significant new rule use
SVHC	Substances of very high concern
TCSCA	Toxic Chemical Substances Control Act
UCMR	Unregulated contaminant monitoring rule
U.K.	nited Kingdom
UNEP	United Nations Environment Programme
U.S.	United States
U.S. EPA	United States Environmental Protection Agency
U.S. FDA	United States Food and Drug Administration
WSC	World Semiconductor Council
WTP	Waste treatment plant
ZDHC	Zero Discharge of Hazardous Chemicals Group

EXECUTIVE SUMMARY

Per- and polyfluoroalkyl substances (PFASs) have been in use since the 1950s as ingredients or intermediates of surfactants and surface protectors for assorted industrial and consumer applications. Some of the unique physicochemical properties of PFASs that popularised their widespread use are also associated with environmental and human health concerns. For example, within the past decade, several long-chain perfluoroalkyl acids have been recognised as persistent, bioaccumulative, and toxic. Many have been detected globally in the environment, biota, food items, and in humans. This has led to efforts toward the development of risk reduction approaches, with the goal to reduce the global impact of these chemicals on the environment and health and to support a global transition toward safer alternatives.

In 2015, the OECD/UNEP Global PFC Group[1] conducted a project, the objective of which was to provide a snapshot of current activities with regard to the development of risk reduction approaches for PFASs in a number of countries. This analysis can then inform countries about options for risk reduction of PFASs. The project is based on a survey activity carried out in the first quarter of 2015; responses were then analysed and put together in the present report. The survey addressed questions related to: (1) the pre-existing conditions necessary for the development and implementation of risk reduction approaches in a particular country/region; (2) the strengths of the different approaches and the benefits gained from their implementation; and (3) the challenges faced during their development and implementation. It aimed to identify risk reduction approaches across participating countries, including national and regional regulatory measures, voluntary industry initiatives, and stewardship programmes.

This survey activity was not intended to prioritise or rank responses from any one country or region but to better inform intergovernmental discussions and increase awareness on the risk reduction programmes for PFASs across countries. The development of this project was based on the active participation of the following countries/regions: Australia, Canada, Denmark, the European Union, Finland, Germany, Japan, the Netherlands, Norway, the

1 The OECD/UNEP Global PFC Group was established in 2012 to facilitate the exchange of information on PFCs and to support a global transition towards safer alternatives. The Group operates under a mandate of the International Conference on Chemicals Management and is supported jointly by OECD and UNEP. It brings together experts from developed and developing countries in academia, governments, industry and NGOs. For more information about the work of the OECD/UNEP Global PFC Group, see http://www.oecd.org/ehs/pfc/.

People's Republic of China, Poland, the Republic of Korea, Sweden, the United Kingdom and the United States (see Table 1). Non-survey information on Russia is included in the report.

Table 1. Summary of risk reduction approaches for PFASs across countries/regions (as of June 2015)

	Regulatory Approach	Policy Approach[2]	Voluntary Initiatives	Other initiatives
Australia	•	•	•	Monitoring
Canada	•	•	•	Monitoring
Denmark		•	•	•
European Union	•			Assessment (especially of several alternatives)
Finland	*See EU Actions*			
Germany	•			Dialogue - increase awareness for industry and public
Japan	•			Monitoring
Netherlands	*See EU Actions*			
Norway	•	•		Monitoring
People's Republic of China	•	•		Monitoring
Poland	•		•	
Republic of Korea	•	•		Monitoring
Sweden	•		•	Literature search/survey/monitori ng
United Kingdom	*See EU Actions*			
United States	•		•	Monitoring

Analysis of responses received from participating delegations indicated that risk reduction approaches for PFASs are mainly covered under existing national and/or regional regulatory frameworks. Risk reduction approaches,

2 A "policy approach" refers to political goals or use of non-regulatory lists to encourage minimization of a substance in the absence of regulatory actions.

in general, cover principally long chains PFASs[3] and their precursors and salts (see Table 2). Approaches aiming at gathering new knowledge (e.g. of the risks of PFASs and of their use in products) and at awareness-raising tend to include broader categories of PFASs (e.g. all PFASs or PFASs with 4 or more perfluorinated carbons). The type of risk reduction approaches implemented across countries can vary but there is often a combination of voluntary and regulatory approaches that is used. Many countries require that regulatory

Table 2: Risk Reduction Approaches for PFAS category by country/region (as of June 2015)

	PFHxS	PFOS	PFSA Higher Homologues	PFOA	PFNA	PFCA Higher Homologues
Australia	•	•	•	•	•	•
Canada				•	•	•
Denmark	•	•	•	•	•	•
European Union		•		•	•	•
Finland	*See EU actions*					
Germany	•	•	•	•	•	•
Japan		•				
Netherlands	*See EU actions*					
Norway	•	•	•	•		
People's Republic of China		•		•		
Poland		•		•		
Republic of Korea		•		•		

3 Long-chain perfluoroalkyl substances refers to:

Perfluorocarboxylic acids with carbon chain lengths C8 and higher, including perfluorooctanoic acid (PFOA);

Perfluoroalkyl sulfonates with carbon chain lengths C6 and higher, including perfluorohexane sulfonic acid (PFHxS) and perfluorooctane sulfonate (PFOS); and

Precursors of these substances that may be produced or present in products.

	PFHxS	PFOS	PFSA Higher Homologues	PFOA	PFNA	PFCA Higher Homologues
Sweden		•	•	•		•
United Kingdom	*See EU actions*					
United States	•	•	•	•	•	•

approaches be supported by risk assessment demonstrating need to reduce risk and exposure. Some also require that a socio-economic or cost-benefit analysis be conducted. While many countries have conducted their own analyses on PFASs, others indicated their use of published assessments from their international counterparts to save resources and avoid duplication of efforts.

The analysis of the risk reduction approaches in the studied countries highlighted a number of initial conditions that tend to influence the development of risk reduction approaches. Two important drivers are the growing scientific knowledge on the risk of certain PFASs for human health and the environment and the increasing number of international initiatives supporting a transition toward safer alternatives. The majority of surveyed delegations chose to prioritise certain long-chain PFASs for risk reduction based on scientific evidence, and international initiatives on PFASs (e.g. the listing of PFOS and related compounds under Annex B of the Stockholm Convention) also led many countries to take domestic measures to reduce risks.

Several surveyed countries/regions noted the importance of multi-stakeholder participation to inform the development of risk reduction approaches. Key stakeholders include: public authorities, industry, academics and advocacy groups. Governments play the primary role in developing and implementing PFAS risk reduction approaches across the surveyed countries/regions and have thus been responsible for convening stakeholders. Industry has helped to provide valuable research and monitoring data on PFASs and developed alternatives. Industry's participation in voluntary approaches has also helped to establish realistic phase-out timelines, reduction targets, and reporting and accountability frameworks, often reaching goals ahead of regulations. Advocacy groups have helped to incite action by voicing concerns about the health and environmental effects of PFASs, and the research community has provided necessary scientific data on which to base prospective risk reduction approaches.

Many countries evaluate the success of their strategies both qualitatively and quantitatively. For example, governments commonly measure the success of risk reduction approaches by tracking emissions levels and production and use information in their country. However, a number of challenges were identified that makes difficult both the elaboration of the approach and the evaluation of its impact. Some of the challenges are:

- The availability of robust scientific data to elaborate a risk reduction approach - these data gaps are especially a challenge when they exist for alternatives;

- The difficulty to gather the necessary information on the use of specific substances all along the supply chain;

- The fact that PFAS risk reduction approaches can be difficult to implement for industry. Alternatives need to be available and approved by regulatory bodies for use, economically cost-effective and technically suitable;

- The variation that exists among the risk reduction approaches regarding articles. For example, it may be difficult to identify chemicals in articles if their ingredients are not required to be labelled. When the components of an article are unknown, it is difficult to assess their risks and therefore manage them. It is also difficult to prohibit the importation of foreign-manufactured items from countries that have no risk reduction approaches in place;

- The challenges that may still arise during enforcement. For example, one country highlighted a lack of cost-effective and available technologies to dispose and/or destroy PFAS-contaminated materials at the volumes required.

Several best practices emerged based on the analysis of responses from the surveyed delegations:

- Risk reduction approaches should be science-based;

- Risk reduction approaches should be developed in consultation with stakeholders;

- A phased approach to risk reduction, such as starting with voluntary or policy approaches, should be considered when scientific data are lacking but there are emerging concerns (e.g. where early risk management actions are used to inform the development of further action), particularly when scientific data are lacking or more time is needed to prepare scientific or economic assessments to support regulatory action;

- International collaboration should be encouraged;

- Quantitative benefits from the risk reduction approaches should be measured and communicated;

- Timelines for action with ambitious targets should be established.

It is envisioned that a survey like the one presented in this report could be repeated and that the report could be regularly updated, with participation from more countries from different regions in the future in order to provide a global picture of risk reduction approaches.

INTRODUCTION, OBJECTIVES AND BACKGROUND

The OECD/UNEP Global PFC Group was established to respond to the International Conference on Chemicals Management (ICCM 2) 2009 Resolution II/5, calling upon intergovernmental organizations, governments and other stakeholders to "consider the development, facilitation and promotion in an open, transparent and inclusive manner of national and international stewardship programmes and regulatory approaches to reduce emissions and the content of relevant perfluorinated chemicals of concern in products and to work toward global elimination, where appropriate and technically feasible". Further work on this resolution was reaffirmed at ICCM 3 Resolution III/3 noting that a significant need remains for additional work to support implementation of resolution II/5. This work is conducted within the framework of the OECD/UNEP Global PFC Group.

The report analyses in-development and in-place risk reduction approaches for per- and polyfluoroalkyl substances (PFASs) in a number of OECD countries and other economies. Risk reduction approaches include national and regional regulatory measures, voluntary industry initiatives and risk management programmes such as rules for use and voluntary controls. The report aims to highlight (i) the pre-existing conditions necessary for the development and implementation of risk reduction approaches in the studied countries, (ii) the strengths of the different approaches and the benefits gained from their implementation, and (iii) the challenges faced during their development and implementation.

Per- and poly-fluorinated chemicals (PFCs)[4], now most frequently referred to as per- and polyfluoroalkyl substances (PFASs), have been in use since the 1950s as ingredients or intermediates of surfactants and surface protectors for assorted industrial and consumer applications. These substances exhibit many desirable and distinct properties including high surface activity, ultra-low surface tension, high thermal and chemical stability, acid resistance, and simultaneous repellence to both water and oil (Wang, Wang, Liao, Cai, & Jiang, 2009; Zushi, Hogarh, & Masunaga, 2012). The highly stable carbon-fluorine

4 PFCs refer here to per- and poly- fluorinated chemicals, and not to perfluorocarbons. Perfluoroalkyl substances refer to those for which all hydrogen atoms attached to carbon atoms have been substituted with fluorine atoms (except for hydrogen atoms whose replacement would change the properties of the present functional groups). Polyfluoroalkyl substances refer to those for which all hydrogen atoms attached to at least one (but not all) carbon atoms have been replaced by fluorine atoms (Buck *et al*. 2011).

bond and the unique physicochemical properties of PFASs have led to their extensive use in various industries worldwide. The wide variety of uses reflects the versatile applications of this group of substances. For example, one use is in fire-fighting foam where they serve as the active ingredient for extinguishing preferably solvent-based fires. Specific non-polymeric PFASs have been used as an active ingredient in ant baits that target leaf-cutting ants, red imported fire ants, and termites. They are also used as surfactants in hard metal plating and decorative plating to protect workers from Chromium-VI emissions. One important application of certain perfluoroalkyl carboxylic acids (PFCAs) is as polymerization processing aids in fluoropolymer manufacturing. Some polymeric PFAS uses well-known to consumers are in non-stick cookware (mainly fluoropolymers) and as water and oil repellents in upholstery, leather, carpets, textiles, and paper, where mainly side-chain fluorinated polymers are utilized (OECD, 2013; Paul, Jones, & Sweetman, 2008; Zushi, et al., 2012).

Some of the unique physicochemical properties of PFASs that popularized their widespread use are also associated with environmental and human health concerns. Given the large number of different compounds of this type, it is difficult to generalize concerns with their production and use. However, within the past decade, several long-chain perfluoroalkyl acids (PFAAs)[5] have been recognised as persistent, bioaccumulative, and toxic (PBT). Many have been detected globally in the environment, biota, food items, and in humans. This has led to efforts toward the development of risk reduction approaches, with the goal to reduce the global impact of these chemicals on the environment, safety and health and to support a global transition toward safer alternatives - see Table 3. Since 2000, there has been global attention given to long-chain PFAAs and their precursors due to PBT characteristics, and detection in human blood, with a trend towards restricting their production and use. Initially, most attention was given to perfluorooctane sulfonic acid (PFOS) and then to perfluorooctanoic acid (PFOA), the two most studied long-chain PFAAs with regard to human health and environmental toxicity. Lately, more attention has also been given to other long-chain PFAAs and their precursors (such as PFHxS, PFNA, PFDA and C_{11}-C_{14} PFCAs). Recent efforts undertaken by the Organisation for Economic Co-operation and Development (OECD), the United Nations Environment Programme (UNEP), and other organisations have sought to characterize the existing landscape of PFAS use and management strategies, through efforts such as the *OECD/UNEP Global PFC Group Synthesis paper on per- and polyfluorinated chemicals (PFCs)* (OECD, 2013), the UNEP Workshop on Managing Perfluorinated Chemicals and Transitioning to Safer Alternatives

5 See a definition of long-chains PFAA at: http://www.oecd.org/ehs/pfc/

(UNEP, 2009b), and three OECD surveys on the production and releases of PFCs globally (OECD, 2005, 2006, 2011) and a document summarizing available information on PFCA emissions (OECD, 2015). This report aims to build upon or complement this previous work through the analysis of in-development and in-place risk reduction approaches to these chemicals across jurisdictions.

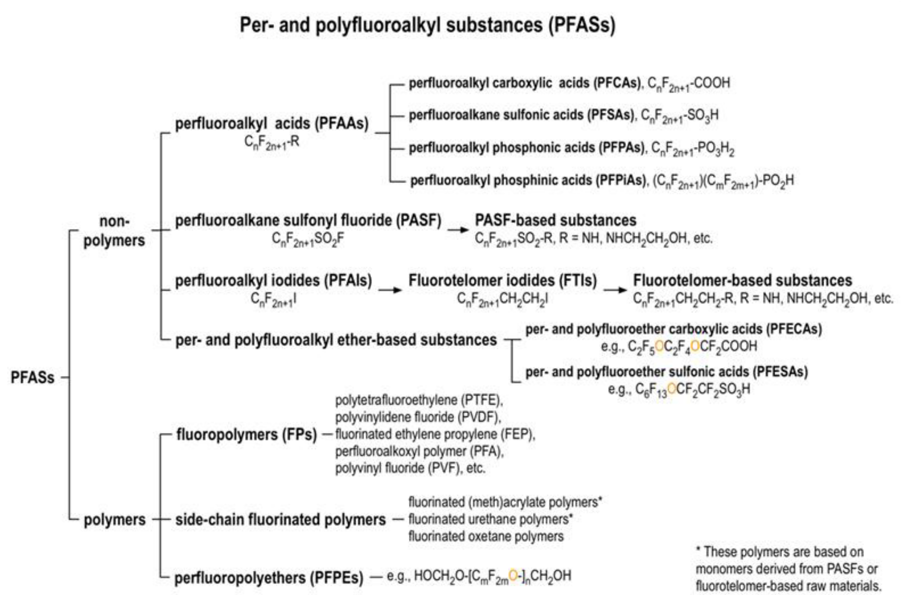
The analysis in this report is based primarily on information collected from delegations on risk reduction approaches for PFASs and further supplemented by desk research. The information gathering activity, carried out in early 2015, was specifically intended to provide a snapshot of current activities across the participating countries with regard to the development of risk reduction approaches for PFASs. It aimed to identify risk reduction approaches across participating delegations, including national and regional regulatory measures, voluntary industry initiatives, and stewardship programmes. It also sought information, when available, on (1) the pre-existing conditions necessary for the development and implementation of risk reduction approaches in a particular country/region; (2) the strengths of the different approaches and the benefits gained from their implementation; and (3) the challenges faced during their development and implementation.

The analysis in this report is not intended to prioritise or rank responses from any one delegation or region but to better inform intergovernmental discussions. To that end, data collection in areas of shared interest in this survey may help support and inform future intergovernmental discussions and research-related activities on PFASs. The development of this project was based on the active participation of 15 delegations: Australia, Canada, Denmark European Union (EU), Finland, Germany, Japan, the Netherlands, Norway, People's Republic of China, Poland, the Republic of Korea, Sweden, United Kingdom (UK), and United States (US).

The risk reduction approaches covered by the report include those that are used to control any aspect of the life cycle from the design and development stage to the manufacture, use, handling/storage, import, export, release and ultimate disposal of the chemicals and articles containing them. The report covers risk reduction approaches for PFASs in commerce (and in articles), and in particular long-chain PFASs. Given the large number of different PFAS compounds (e.g., differences in chain length, molecular weight, fluorination pattern), this report categorizes these substances into groups with similar properties for simplicity (see Box 1).

Box 1. General Classification of PFASs

Figure 1. General classification of per- and polyfluoroalkyl substances (PFASs) based on the a commonly agreed terminology for nomenclature of PFASs (Buck et al. 2011); this figure is reproduced from OECD (2013) and updated with new information available



WHAT ARE PFASS AND WHY THERE IS A CONCERN: HISTORICAL PERSPECTIVE ON THE DEVELOPMENT OF PFAS RISK REDUCTION APPROACHES

PFASs are man-made chemicals that were first created over 70 years ago. Polytetrafluoroethylene (PTFE) – a fluoropolymer or polymeric PFAS - was discovered in 1938 and was later introduced under DuPont's Teflon® brand in 1949. The product was eventually approved by the US Food and Drug Administration (US FDA) in 1962 for use in cookware. Five years later in 1967, the US FDA also approved the use of one DuPont Zonyl® fluorotelomer-based product in food packaging. In the same timeframe, 3M began selling its stain repellent Scotchguard™ in 1956 that was based on PASF chemistry. Between 1970 and 2002, 3M was the leading manufacturer of perfluorooctane sulfonyl fluoride (POSF), with an estimated total cumulative global production of 96,000 tons within this time period (Lindstrom, Strynar, & Libelo, 2011) and perfluorooctanoic acid (PFOA), with an estimated cumulative global production ranging from 3,600 tons to 5,700 tons (Prevedouros et al., 2006; Wang et al., 2014); smaller producers exist in Asia (Xie, 2013) and existed in Europe (Paul, et al., 2008).

The pre-market testing of new materials required in many jurisdictions today was not the norm when PFASs were first brought to market in the 1950s. However, as the production and use increased in subsequent decades, interest in evaluating the potential environmental and human health effects associated with exposure to these substances grew (Lindstrom, et al., 2011). Research conducted as early as the 1960s and 1970s by D.R. Taves identified that certain long-chain PFASs were present in the serum of human blood (Lindstrom, Strynar et al. 2011. Further testing and monitoring found that by the 2000s, measurable quantities of certain long-chain PFSAs and PFCAs were found globally in human blood samples and that the compounds were distributed throughout the environment. These substances have been found in many different environmental media including aquatic ecosystems, drinking water, outdoor and indoor environment, and food products (Zushi, et al., 2012). The compounds have also been found in remote areas such as the Arctic, revealing their ability to undergo long-range transport (OECD, 2013).

Because of the concerns outlined above, in May 2000, following negotiations between the US EPA and 3M, 3M announced its voluntary manufacturing phase out of PFOS and its commitment to finding substitutes (Santoro, 2008). At the time, 3M was the sole manufacturer of PFOS in the US (U.S. EPA, 2000). By the end of 2000, 3M reduced its PFOS production by 90 percent primarily by no longer manufacturing protective chemicals, surfactants, and consumer products containing the substance. Two years later, the company had completely ceased the production of PFOS globally (Santoro, 2008).

In addition to the voluntary phase-outs of certain PFASs, voluntary stewardship programs have served as a risk reduction strategy for manufacturers and downstream users. These programs have been facilitated through governments as well as through industry associations. The first government-led stewardship program of this kind was established in 2006 by the United States Environmental Protection Agency (U.S. EPA), under which eight major fluoropolymer and fluorotelomer manufacturers (Arkema, Asahi Glass, Ciba (now BASF), Clariant (now Archroma), Daikin, DuPont, 3M, Solvay) committed to reducing and eventually eliminating the use of PFOA, precursor chemicals that can break down to PFOA, and related higher homologue chemicals by 2015 globally (U.S. EPA, 2015). Other voluntary approaches are described later in the report in the chapter "Voluntary Risk Reduction Measures taken by Corporations".

The development of regulatory measures has also been commonly used as a risk reduction approach for certain PFASs. As elaborated further in the report, to date these have included reporting requirements, as well as the prohibition, management, and restriction of the manufacture, use, sale, offer for sale, import, and export of certain long-chain PFASs or articles containing them. International initiatives have also influenced the regulation of certain long-chain PFASs globally. PFOS and related compounds were listed under Annex B of the Stockholm Convention for Persistent Organic Pollutants (POPs) in 2009, restricting their production and use in the 100+ ratifying countries (UNEP, 2009a).

It is important to note that the uses of PFOS (and related compounds) have been placed into two groups: critical uses and non-critical uses. A critical use is a use for which there is currently no technically or cost feasible substitute available. In general, critical uses are dominated by industrial processes and intermediates, while non-critical uses are dominated by consumer products (Swedish Chemicals Inspectorate, 2005). A look at the inclusion of PFOS and related compounds under Annex B of the Stockholm Convention on POPs gives insight into some of the critical uses of PFOS (see Box 2). In 2006, the trade associations World Semiconductor Council and Semiconductor Equipment and Materials International announced a plan to end non-critical uses of PFOS

Box 2. An overview of Annex B of the Stockholm Convention on POPs

Inclusion under Annex B restricts, but does not eliminate, the production and use of PFOS and related compounds. This restriction (rather than ban) allows for the production and use of PFOS and related compounds for specific purposes, i.e., those for which currently no technically feasible substitutes exist. The acceptable purposes under Annex B for PFOS and related compounds include use as, or as an intermediate in the production of chemicals used in the following applications: photo-imaging; photo-resist and anti-reflective coatings for semi-conductor; etching agent for compound semi-conductor and ceramic filter; aviation hydraulic fluids; metal plating (hard metal plating) only in closed-loop systems; certain medical devices (such as ethylene tetrafluoroethylene copolymer (ETFE) layers and radio-opaque ETFE production, in vitro diagnostic medical devices, and CCD colour filters); fire-fighting foam; and insect baits for control of leaf-cutting ants.

Annex B also lists applications for which specific exemptions must be granted in order to produce or use the PFOS and related compounds. The specific uses for which special exemptions are required equate to those uses for which technically feasible substitutes are deemed available, i.e., non-critical uses. For PFOS and related compounds listed under Annex B, these include: photo masks in the semiconductor and liquid crystal display (LCD) industries; metal plating (hard metal plating); metal plating (decorative plating); electric and electronic parts for some colour printers and colour copy machines; insecticides for control of red imported fire ants and termites; chemically driven oil production; carpets; leather and apparel; textiles and upholstery; paper and packaging; coatings and coating additives; and rubber and plastics.

Source: (UNEP, 2009a)

chemicals in semiconductor manufacturing and to work to identify substitutes for PFOS in all critical uses in line with the uptake of PFOS in Annex B of the Stockholm convention. These efforts, as well as similar ones, are discussed in more depth later in the report in the chapter “Voluntary Risk Reduction Measures taken by Corporations”.

Many chemical and product manufacturers have since 2000 made efforts to replace LC PFASs with alternative chemicals or non-chemical techniques. The three types of LC PFAS alternatives available are: (1) substances with shorter per- or polyfluorinated carbon chains; (2) non-fluorine-containing substances; and (3) non-chemical alternatives (OECD, 2013). Toxicity data for some of these substances have been published or made publically available while some test results have been made available to regulatory agencies only (for confidentiality reasons), or may not have been required in countries with less stringent pre-commercialization testing requirements (OECD, 2013). However, there are still considerable information and knowledge gaps regarding PFASs, other than PFOA and PFOS. This includes limited information on levels in environmental media and in humans and the toxicity data that is available indicate effects on humans and the environment (Nordic Council of Ministers, 2013).

SUMMARY OF PFAS RISK REDUCTION APPROACHES IN DIFFERENT ECONOMIES

This section summarizes in-development and in-place risk reduction approaches across 15 economies. Information for the following 12 economies is primarily based on survey responses: Australia, Canada, the Denmark, European Union, Finland, Germany, Japan, the Netherlands, Norway, Poland, the Republic of Korea, Sweden, the United Kingdom, the United States and the Peoples' Republic of China. Information on Russia is solely based on information in the public domain. A short description of risk reduction approaches for each economy is provided below, and Table 3 compares risk reduction approaches across economies.

Australia

Per- and polyfluoroalkyl substance (PFASs) are not manufactured in Australia. Australia's approach to risk reduction is a combination of voluntary and regulatory actions focused on reducing the use and import of some PFASs (i.e. long-chain non-polymer PFASs). Australia's approaches do not address manufactured items (articles). The regulatory approach, implemented under the *Industrial Chemicals (Notification and Assessment) Act of 1989* (the ICNA Act), requires industry to provide toxicity data for new substances including PFASs or products containing new PFASs being introduced into Australia. Based on the level of toxicity and environmental persistence, the National Industrial Chemicals Notification and Assessment Scheme (NICNAS) recommends restrictions on how these substances can and cannot be used. Assessment of new and existing PFASs result in recommendations for the management of import of new PFASs that have improved risk profiles but are still persistent. The ICNA Act also requires the introducers of new PFASs to inform NICNAS of any changes in circumstances that would affect the results of existing NICNAS risk assessments on these chemicals. The voluntary approaches include raising awareness of industry of the hazards of the chemicals and monitoring the manufacture, import, and use of PFASs. PFASs use is also limited by Air Services Australia, a government-owned corporation that provides air traffic control management; it has transitioned away from fluorinated fire-fighting foam to non-fluorinated firefighting foam including the destruction of remaining stockpiles.

To measure benefits associated with the implementation of these approaches, NICNAS conducted a survey in 2008 to collect use and import data on PFASs (specifically non-polymer PFSAs). The survey indicated an increase in PFSAs and related compounds from previous years with substantial changes in the type of imports and the use patterns. The survey also indicated a switch to fluorotelomer-based substances and shorter chain PFSAs (i.e. PFBS). This trend represents a key challenge in the implementation of these risk reduction strategies given the lack of data on the long-term effects of short-chain PFSAs and their degradation products.

In terms of successes to date, a recent study (Toms et al., 2014) provided strong evidence that there are decreasing serum PFOS and PFOA concentrations in an Australian population from 2002-2011.

Canada

Canada has implemented a combination of regulatory and voluntary actions to reduce the risk of certain long-chain PFASs as shown in Table 3. In 2006, Canada launched their "Action Plan for the Assessment and Management of Perfluorinated Carboxylic Acids and their Precursors" (Environment Canada, 2006).

For their regulatory approaches, Canada has prohibited the manufacture, use, sale, offer for sale, and import of four fluorotelomer-based substances and PFOS with some exemptions. Recently, Canada has also published proposed regulations that would prohibit the manufacture, use, sale, offer for sale and import of PFOA and long-chain PFCAs with some exemptions. In addition, Canada has issued prohibitions on any new long-chain perfluorocarboxylic acid (PFCA) precursors that are notified under the New Substances Notification Regulations. The regulations are a result of efforts by Environment Canada and Health Canada.

Both departments also play an integral role in the country's current voluntary program which seeks to reduce residual PFCA through annual industry reporting on progress made towards eliminating residual PFOA, C_{9}-C_{20} PFCAs, and precursors in products sold in Canada. In 2010, Environment Canada, Health Canada and four companies (Arkema Canada Inc., Asahi Glass Company Ltd., Clariant Canada Inc., and E.I. DuPont Canada Company) signed an Environmental Performance Agreement that is in effect until December 31, 2015. This agreement is a key component of a comprehensive risk management strategy for PFCAs. In regards to the measured benefits, signatories of Canada's voluntary program have reported reductions in the content of PFOA, C9-C20 PFCAs, their salts, and precursors. The reductions that have been reported from baseline years range from 66% to 100% (Environment Canada, 2010). Additionally, a success of the risk reduction voluntary approach is that the signatories have stated they expect to reach full elimination of these chemicals by the end of 2015. Another benefit of the voluntary approach was its ability to allow Canada to address one of its key challenges in developing and implementing risk reduction approaches – the availability of scientific data. Specifically, the Government of Canada took a tiered approach of using early voluntary risk management actions while additional risk assessment analysis was undertaken to support the development of additional regulatory risk management action.

In 2006 Canada initiated monitoring of PFOA, PFCAs, PFOS, their salts and their precursors in several media including air, water, sediment, aquatic and terrestrial biota, wastewater and biosolids. In addition, Canada has also undertaken biomonitoring of these substances as part of the Canadian Health Measures Survey. These results provide an important piece of information to be used by the Government of Canada in evaluating their risk reduction approaches for these substances (Health Canada, 2010; Health Canada, 2013; Gewurtz, 2013; Environment Canada, 2013; Tittlemier, 2006).

Denmark

Denmark addresses certain PFASs through EU regulations. In addition the Danish Environmental Protection Agency included PFOA and PFOS compounds in The List of Undesirable Substances (last updated in 2009) to encourage industry phase out. The Danish Environmental Protection Agency also has recently requested an evaluation of health hazards by exposure to the perfluoroalkylated substances, PFOA, PFOS and PFOSA. Additional PFAS substances have furthermore been selected for a preliminary screening in relation to toxicity in order to assess the possibilities for derivation of specific quality criteria for the substances (see http://mst.dk/service/publikationer/publikationsarkiv/2015/apr/perfluoroalkylated-substances-pfoa-pfos-and-pfosa/). On the basis of this evaluation, limit values for 12 PFAS substances have been set in soil (0,4 mg/kg TS), drinking water and ground water (0,1 µg/l) leading to activities linked to monitoring and screening of PFASs (see Table 3).

A survey of the effects of short chained PFASs on health and environment has also been requested by the Danish Environmental Protection Agency as well as a report on fluor-free alternatives to PFAS in textiles. A report on exposure and migration of PFAS from textiles for children's wear is in press.

These reports will be used in the further work on risk reduction approaches for this group of substances.

European Union

EU has taken a regulatory approach to reduce risks to certain PFASs to "ensure a level playing field" in the EU market. Regulations to reduce PFOS, PFOA, and APFO have been developed in collaboration with advocacy groups, industry, and the research community. Specifically, PFOS has been prohibited/restricted in its use, production, import, and export under EU Commission Regulation No 757/2010 of 24 August 2010 a regulation that complements provisions of international agreements on POPs. In addition PFOS is proposed to be included as priority hazardous substance in Directive (COM(2011)876) amending the Water Framework Directive (2000/60/EC) and Directive on Environmental Quality Standards (Directive 2008/105/EC).

PFOA/APFO and C_{11}-C_{14} PFCAs are listed as substances of very high concern (SVHC) under the EU Chemicals Regulation REACH, which requires registration, notification, and duty to communicate on articles that contain these PFASs with the ultimate aim to substitute the substances completely. PFOA and AFPO are also required to be classified, labelled, and packaged under regulation EC No 1272/2008 and there is a ban on placing these chemicals on the market as substances, constituents of other substances, or in mixtures for supply to the general public. A comparable classification and labelling is proposed for PFNA, and PFDA by Sweden. Additionally, PFOA, its salts and related substances have been proposed to be restricted under REACH. Legislative proposals in the EU are subject to risk and socio-economic analysis by the European Chemicals Agency (ECHA) and alternatives are considered by ECHA in the decision making process.

Finland

Finland addresses risk reduction of certain PFAS through EU regulations. Actions have been largely concentrated on PFOS phase-out and the risks related to its alternatives. There is no PFOS production in Finland. Finland has conducted a survey on the use of PFOS and related substances as well as their alternatives in metal plating. In the past, the largest open application in Finland is assumed to have been the use of PFOS containing firefighting foams (inventory established in 2006 and 2008), which has been prohibited since 2011. Consequently Finland has carried out a screening study on the possible sites with ground water and surface water contamination from use of AFFF with a view to evaluate the possible risk on drinking water supplies. A proposal of a limit value for PFOS in drinking water is under consideration. Finland has also done sporadic screening of PFAS compounds in fish since 2009 and surface and ground waters since 2014. Voluntary awareness raising campaigns to representatives of various sectors has also been accomplished.

Germany

Germany addresses chemical risk management mainly through EU regulations. In addition, Germany is engaging in dialogues with stakeholders to exchange information and signal to industry concerns related to PFASs and to convey information to the public. This dialogue also includes the feasibility of alternatives. In addition, Germany developed threshold and guide values to limit the amount of PFCAs and PFSAs in drinking water and sludge and developed a background document *Do without per-and polyfluorinated chemicals and prevent their discharge into the environment* (German Federal Environment Agency, 2009). Moreover, Germany and fire-fighting associations compiled a leaflet on PFCs in fire-fighting (German Federal Environment Agency et al, 2013). These programs have resulted in an increased awareness of the risks associated with certain PFASs by industry, NGOs and the public. In developing these approaches, challenges that Germany has encountered include the number of chemicals within the PFAS group, the multitude of uses of the substances, and the availability of data.

Japan

Japan has listed PFOS and its salts as a Class I Specified Chemical Substance under the Chemical Substances Control Law (CSCL) and PFOS is subject to export restriction under the country's Foreign Exchange and Foreign Trade Law. The Class I listing occurred in response to the new listing of PFOS under the Stockholm Convention after the government evaluated if PFOS and its salts were persistent, bioaccumulative, and have long-term toxicity for humans and animals. Additionally, the government of Japan has been conducting environmental monitoring of PFOS since 2009.

The Netherlands

As shown in Table 3, the Netherlands addresses certain PFASs under EU regulations. There are no PFOS production facilities in the Netherlands. The Netherlands noted that allowed within the EU are about eight PFOS applications. The need to apply PFOS for these applications is checked on a regular basis for which the companies using these applications are approached. The Netherlands submitted their inventory to the Stockholm Convention in 2014. Of main concern are the open applications in which high amounts of PFOS are applied. The largest open use, application of PFOS in fire-fighting foam, is prohibited since 27 June 2011.

Norway

Norway listed several long-chain PFASs on its national list of priority substances starting in 2003, based on monitoring data that showed high levels of these substances in the environment as well as their toxicological profiles.

Norway's approach to risk reduction has primarily been a combination of information dissemination and regulatory measures, administered by the Norwegian Environment Agency under the Ministry of Climate and Environment. Regulatory measures on PFASs have been developed in communication with industry. All regulatory measures must be supported by risk assessments and cost-benefit analysis, which consider the availability of alternatives. Regulatory measures include monitoring and clean-up of PFAS-polluted soil at airport fire drill sites, waste treatment plant (WTP) discharge permits for select PFASs, analysis of PFAS in consumer products, and a national ban on the manufacture, production, import, and placing on the market of consumer products containing PFOA.

To measure benefits associated with implementation, Norway performs a yearly analysis of the discharge, use, and levels found in the environment of its national priority substances. Levels of PFASs are measured in consumer products as part of compliance checks of the Norwegian ban on those substances. However, as the ban relates to many different product groups with manufacturers all over the world, information collection and compliance checks have been challenging for Norway.

In terms of successes to date, levels of PFASs have generally shown a decreasing trend in environment and humans. However, a large proportion of the PFAS pollution in Norway is likely caused by long-range transport and it is therefore difficult to establish which specific actions are responsible for the decline. The Norwegian ban of PFOA in consumer products has prompted manufacturers to speed up the process of phasing out PFOA.

People's Republic of China

In 2008, the Ministry of Environmental Protection (MEP) issued the first batch of "High Pollution, High Environmental Risk Product Catalogue" which includes high temperature melting membrane fluorine resin coating used on non-stick cookware, kitchenware, and food processing machinery, based on the potential residual PFOA in the products. In 2011, the National Development and Reform Commission issued "Industrial Recon-structuring Guide Directory" restricting the production of PFOS and PFOA and encouraging the research and development on alternatives of PFOS and PFOA. In 2014, MEP issued announcement No.[2014]21, banning "production, transportation, application, imports and exports of PFOS, its salts, and perfluorooctane sulfonyl fluoride (PFOSF), except for specific exemptions and acceptable use."Also in 2014, MEP issued the announcement No.[2014]33, listing 8 PFOS chemicals in the "Key Hazardous Chemicals Catalogue of Environmental Management"

Acceptable Purpose	Specific Exemption
Photo-imaging;	Photo masks in the semiconductor and liquid crystal display (LCD) industries;
Photo-imaging;	Metal plating (hard metal plating);
Photo-resist and anti-reflective coatings for semi-conductors;	Metal plating (decorative plating);
Etching agent for compound semi-conductors and ceramic filters;	Electric and electronic parts for some colour printers and colour copy machines;
Metal plating (hard metal plating) only in closed-loop systems;	Insecticides for control of red imported fire ants and termites;
Aviation hydraulic fluids;	Chemically driven oil production.
Fire-fighting foam.	

China started a research and development project on "PFOS Alternatives for Plating Mist Suppressing Agent and Fabric Finishing Agent" as part of China's "Eleventh Five Year Plan". A new patent for fog inhibitor was registered through this project but is not commercialised. Perfluorinated sulfonic acid butyl acrylate based finishing agent, as alternative to PFOS, was found with good performance as waterproof agent but did not have good performance as an oil repellent.

Since 2013, China monitors PFC production and/or emissions, focusing on PFOS and sulphonamide perfluorooctane (FOSA) in water, sediment and fishes in industry parks in Hubei and Zhejiang Provinces. It also focuses on PFOS and PFOA in water, sediment and fish, and in an electronic waste dismantling plant in Guangdong Province. The Second Effectiveness Evaluation of the Stockholm Convention in China has started to monitor PFOA and PFOS environmental background levels in air and water of mainland China, Hong Kong (China) and Macau (China).

Poland

Poland addresses certain PFASs under EU Regulations. All the actions taken by EU are generally taken in consultation with internal stakeholders in Poland (industry, NGOs). Poland has also taken voluntary action under the Control of Hazardous Substances in the Baltic Sea Region (COHIBA) project to raise awareness on PFOS.

Republic of Korea

The Republic of Korea addresses PFOS, its salts and PFOS-F as restricted substances under the Persistent Organic Pollutants Control Act. Under the Act, any manufacture, import, export and use of PFOS, its salts and PFOS-F are restricted except for specific exemptions and acceptable use in the Stockholm Convention. Since 2013, Korea has implemented environmental monitoring on PFOS, and has also conducted environmental monitoring on PFOA since 2015.

Russia

Regulations regarding certain PFASs in Russia are implemented in accordance with international conventions and agreements including the Baltic Marine Environment Protection Commission (HELCOM, Recommendation 31E/1), the Stockholm Convention on POPs (Annexes A and B), the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemical and Pesticides in International Trade, SAICM, and the current OECD program on the management of PFASs and transition to safer alternatives. Regulatory documents of the Customs Union (Belarus, Kazakhstan and Russia) do not indicate future bans or restrictions on those PFASs that are subject to regulations by international conventions and agreements. However, ammonium perfluorononanoate (APFO) is regulated in Russia in occupational air with a tentative safe exposure level of 0.05 mg/m^3 (Hygiene Norm 2.2.5.2308-07). Additionally, a number of short- and middle-chain PFASs are regulated in occupational air and water, and are generally referred to as low hazardous substances (OECD 2013).

Sweden

Sweden addresses certain PFASs through EU Regulations. Also, as shown in Table 3, the Swedish Chemicals Agency (CA) (KemI) has been assigned by the Swedish government to develop a national action plan with the aim to increase the safety of drinking water supplies. This will be reported to the government by September 2017. KemI has also been assigned to investigate potential national and/or EU regulations and other measurements (specifically for fire-fighting foams but other uses may also be considered). Within the national action plan the Swedish CA is also performing a survey of different PFASs and their uses on the market and the occurrence of alternatives. The Swedish CA will also work for an EU-action plan for the group of PFAS substances. In addition there are also activities by other Swedish agencies which are included in Table 3.

United States

The U.S. Environmental Protection Agency (EPA) uses a combination of regulatory and voluntary approaches, including Significant New Use Rules (SNURs) and the voluntary 2010/2015 PFOA Stewardship Program.

EPA has published four final SNURs (September 30, 2013; October 9, 2007; March 11, 2002; and December 9, 2002) and one recently proposed SNUR (January 15, 2015) to ensure that PFASs that have been phased out from the United States do not re-enter the marketplace without review. SNURs require that anyone who intends to import these chemicals, including in products, or domestically produce or process these chemicals for any new use submit a notification to EPA at least 90 days before beginning the activity. This notice provides the Agency with an opportunity to evaluate the new use and, if necessary, take action to prohibit or limit the activity. Additional information is available at http://epa.gov/oppt/pfoa/pubs/pfas.html.

In addition, since late 1999, EPA has worked with stakeholders to develop hazard and exposure information on PFASs through Enforceable Consent Agreements, negotiated but enforceable agreements among EPA, industry, and interested parties that requires certain signing parties to generate data and submit those data to EPA on a specified schedule. EPA continues to involve stakeholders in subsequent initiatives including industry, NGOs, other Agencies, academics, and the international community. Additional information is available at http://epa.gov/oppt/pfoa/pubs/eca.html.

Industry and the broader research community played a key role in overcoming technological challenges in monitoring and other areas, such as creating PFAS standards, developing instruments capable of measuring PFASs, improving detection levels, handling contamination issues, and addressing scientific issues. Major manufacturers and processors of PFASs participate in the 2010/2015 PFOA Stewardship Program to work toward a phase-out of PFOA and related substances by end of 2015. The program stretched from 2006 through 2015 to provide an opportunity for development of alternatives which did not exist at the time of the launch. Progress toward the 2015 deadline is measured through annual reports. All companies are on track to meet the 2015 phaseout goal. Additional information is available at http://epa.gov/oppt/pfoa/pubs/stewardship/index.html.

Concentrations of certain PFASs in media such as drinking water and in humans are also used as indicators of success. The U.S. Centers for Disease Control and Prevention (CDC) National Report on Human Exposure to Environmental Chemicals (National Exposure Report) consists of a series of ongoing assessments of the U.S. population's exposure to environmental chemicals through biomonitoring. The most recent data released in February 2015 indicate declines of PFOA in blood serum across the US population. Additional information is available at: http://www.cdc.gov/exposurereport/index.html.

The U.S. EPA monitored unregulated contaminants under the third Unregulated Contaminant Monitoring Rule (UCMR3) which includes PFOS, PFOA and other PFSA and PFCA compounds. The most recent report released in January 2015 included data from more than 3,600 public water systems, and showed no results for PFOA above the reference concentration (0.4 ppb) and 12 public water systems above the reference concentration (0.2ppb) for PFOS. Additional information is available at http://water.epa.gov/lawsregs/rulesregs/sdwa/ucmr/data.cfm.

Table 3: Comparison of Risk Reduction Approaches for PFASs across Delegations

	Action	Path Taken	BEPs Implemented[i]	Category of PFASss addressed	Articles covered?	Life cycle stage(s) addressed	Method of approach	Public-private partnership encouraged?	Level of constraint
Australia	Six alerts issued since 2002 containing information on manufacture, import and use of PFASs in Australia, as well as regulatory information on PFCAs and PFSAs. Link to alerts[6]	Increase awareness for industry and public	Minimization of PFASs used	Long-chain PFSAs; PFCAs and related substances	No, except for releases from articles.	Import, formulation, and use	Voluntary	No	None
Australia	Assessment recommendations for new and existing PFASs being re assessed, that are persistent as part of a replacement strategy to phase out longer chain PFASs	Manage the import of new PFCs that have improved risk profiles, but are still persistent.	Minimization of PFASs used	PFASs with 4 or more perfluorinated carbons	No	Chemical introduction; product introduction; product use	Voluntary	No	Reporting obligations regarding changes in use, volume or availability of new information

6 See, http://www.nicnas.gov.au/communications/publications/information-sheets/existing-chemical-info-sheets/pfc-derivatives-and-chemicals-on-which-they-are-based-alert-factsheet

	Action	Path Taken	BEPs Implemented[i]	Category of PFASss addressed	Articles covered?	Life cycle stage(s) addressed	Method of approach	Public-private partnership encouraged?	Level of constraint
Australia	Transition from operational fluorinated fire-fighting foam to non-fluorinated foam, including destruction of remaining stockpiles, in the aviation industry.	Encourage phase-out	Minimization of PFASs used	PFASs in current generation AFFF (including PFOS as by-product)	No	Product use; waste stream	Policy approach	No	No information available
Australia	Additional data requirements for pre-market entry applications for new PFCs	Assess the risks of new PFASs prior to introduction	Minimization of PFASs used	PFASs with 4 or more perfluorinated carbons	No	Chemical introduction; product introduction	Regulatory	No	Application requirements for companies
Canada	Four fluorotelomer-based substances added to the *Prohibition of Certain Toxic Substances Regulations, 2012.* Link to amendment[7]	Prohibit the manufacture, use, sale, offer for sale and import	Minimization of use of precursors	Fluorotelomer-based substances	No	Manufacture, use, sale, and import	Regulatory	No	Full prohibition (excluding manufactured items)

7 See, http://www.gazette.gc.ca/rp-pr/p2/2010/2010-10-13/html/sor-dors211-eng.html

	Action	Path Taken	BEPs Implemented[i]	Category of PFASss addressed	Articles covered?	Life cycle stage(s) addressed	Method of approach	Public-private partnership encouraged?	Level of constraint
Canada	Ministerial prohibitions on any new long-chain PFCA precursor that are notified under the *New Substances Notification Regulations*, as appropriate and consistent with existing restrictions. Link to regulation[8]	Prohibit the manufacture, use, sale, offer for sale and import	Minimization of use of precursors	Long-chain PFCA precursors	No	Manufacture, use, sale, and import	Regulatory	No	Full prohibition (excluding manufactured items)
Canada	Environmental Performance Agreement reached to encourage action from industry to significantly reduce residuals from perfluorinated products sold in Canada.	Manage manufacture and import	Minimization of residual PFOA, $C_9 - C_{20}$ PFCAs and precursors in perfluorinated products sold in Canada	PFOA, $C_9 - C_{20}$ PFCAs, and precursors	No	Product manufacture and import	Voluntary	Yes	Signed agreement requires annual reporting of progress.

8 See, http://www.ec.gc.ca/lcpe-cepa/eng/regulations/detailReg.cfm?intReg=92

	Action	Path Taken	BEPs Implemented[i]	Category of PFASss addressed	Articles covered?	Life cycle stage(s) addressed	Method of approach	Public-private partnership encouraged?	Level of constraint
	Link to agreement[9]								
Canada	Proposed Regulations Amending the Prohibition of Certain Toxic Substances Regulations, 2012 Link to the proposed regulations[10]	Prohibit the manufacture, use, sale, and import	Minimization of PFASs used	PFOA, $C_9 – C_{20}$ PFCAs, their salts and their precursors(excludes aqueous film forming foam for fire-fighting applications, and manufactured items)	No	Chemical and product manufacture, use, sale, and import	Regulatory	No	Full prohibition (excluding manufactured items)
Canada	Perfluorooctane Sulfonate and its Salts and Certain Other Compounds Regulations Link to	Prohibit the manufacture, use, sale, and import	Minimization of use	PFOS its salts and its precursors	Yes	Chemical and product manufacture, use, sale, and import	Regulatory	No	Prohibition with exemptions

9 See, http://www.ec.gc.ca/epe-epa/default.asp?lang=En&n=AE06B51E-1

10 See, http://ec.gc.ca/lcpe-cepa/eng/regulations/detailReg.cfm?intReg=226.

	Action	Path Taken	BEPs Implemented[i]	Category of PFASss addressed	Articles covered?	Life cycle stage(s) addressed	Method of approach	Public-private partnership encouraged?	Level of constraint
	regulation[11]								
Denmark	Included in list of undesirable substances. Link to list[12]	Encourage industry phase out	Minimization of PFASs used	PFOA and PFOS compounds	No	Chemical manufacture	Voluntary	No	None
Denmark	Monitoring and screening of PFASs in the environment Link to survey[13] Link to criteria for 12 PFASs in soil, ground and drinking water[14]	Continuous monitoring		PFBS,PFHxS, PFOS, PFOSA, 6:2 FTS, PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA,		Discharges from all life cycles are addressed	Monitoring	No	Criteria set with a limit of 0,1 µg/l for drinking and ground water. 0,4 mg/kg TS in soil.

11 See, http://ec.gc.ca/lcpe-cepa/eng/regulations/detailReg.cfm?intReg=107

12 See, http://eng.mst.dk/topics/chemicals/assessment-of-chemicals/lous---list-of-undesirable-substances-2009/.

13 See, http://mst.dk/service/nyheder/nyhedsarkiv/2014/okt/undersoegelse-af-perfluorstoffer-i-grundvandet-under-forurenede-grunde/ , http://www2.mst.dk/Udgiv/publikationer/2014/10/978-87-93178-96-0.pdf

14 See, http://mst.dk/service/publikationer/publikationsarkiv/2015/apr/perfluoroalkylated-substances-pfoa-pfos-and-pfosa/

	Action	Path Taken	BEPs Implemented[i]	Category of PFASss addressed	Articles covered?	Life cycle stage(s) addressed	Method of approach	Public-private partnership encouraged?	Level of constraint
	PFOS and its salts are subject to the export restriction under the Foreign Exchange and Foreign Trade Law								system and SDS system
Netherlands	*See EU actions*								
Norway	Monitoring and screening of PFASs in the environment Links to monitoring studies Urban terrestrial environment 2014[23], Urban fjord 2014[24], Milkys 2012[25],	Continuous monitoring	Not relevant	Varies from year to year	Not relevant	Discharges from all life cycles are addressed	Analysis	No	None

15 See, http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:223:0029:0036:EN:PDF
16 SVHC - Substance of Very High Concern
17 See, http://echa.europa.eu/candidate-list-table

	Action	Path Taken	BEPs Implemented[i]	Category of PFASss addressed	Articles covered?	Life cycle stage(s) addressed	Method of approach	Public-private partnership encouraged?	Level of constraint
	Link to candidate list[18]	for safety data sheets				and use.			
European Union	PFOA and APFO harmonised classification under Reg. (EC) No 1272/2008 (2013); Classification, labelling, packaging of dangerous substances and mixtures	Manage the manufacture, sale, import and export	Minimization of PFASs used	PFOA and APFO	No	Chemical manufacture, product (mixtures and articles) manufacture and use.	Regulatory	No	Reporting obligations for companies
European Union	PFOA and APFO covered by Annex XVII entries 28-30 of REACH; Ban on the placing on the market as substances, constituents of other substances or in mixtures for supply to the general public	Manage the manufacture, sale, import and export	Minimization of PFASs used	PFOA and APFO	No	Mixtures for consumer use	Regulatory	No	Reporting obligations for companies

18 See, http://echa.europa.eu/candidate-list-table

	Action	Path Taken	BEPs Implemented[i]	Category of PFASss addressed	Articles covered?	Life cycle stage(s) addressed	Method of approach	Public-private partnership encouraged?	Level of constraint
European Union	Proposal for restriction of PFOA, its salts and PFOA- related substances under REACH (2014). Public consultation ongoing until 17 June 2015.	Manage the manufacture, sale, import and export	Minimization of PFASs used	PFOA, its salts and PFOA- related substances	Yes	Chemical manufacture, product (mixtures and articles) manufacture and use.	Regulatory	No	Reporting obligations for companies
European Union	Several PFASs listed on draft Community Rolling action plan (CoRAP) for substance evaluation within the next years Link to CoRAP list of substances[19]	Evaluation	No information available	Several (especially alternatives to PFOA- and PFOA-related substances)	Will be considered in exposure assessment	Whole life cycle	Assessment	No	None
Finland	*See EU actions*								

19 See, http://echa.europa.eu/information-on-chemicals/evaluation/community-rolling-action-plan/corap-table

	Action	Path Taken	BEPs Implemented[i]	Category of PFASss addressed	Articles covered?	Life cycle stage(s) addressed	Method of approach	Public-private partnership encouraged?	Level of constraint
Finland	Screening of PFASs in the environment	Continuous screening	Not relevant	Primarily PFOS and PFOA	Not relevant	Discharges from all life cycles are addressed	Analysis	No	
Finland	Screening of PFAS polluted soil at airport fire drill sites	Screening/ Risk assessments	No	PFOS and other relevant PFASs	No	End use	Analysis/ Voluntary		None
Finland	Mapping of uses of PFOS and the alternatives on the hard metal plating	Survey	Not relevant	PFOS and its salts	Yes	Use in the production	Interview		None
Finland	Evaluation of drinking water contamination	Screening/ Risk assessments	No	All PFAS	No	Discharges from all life cycles are addressed	Analysis/ Voluntary		None
Germany	Dialogue with stakeholders to exchange information and convey concern re: PFASs, and provide information to	Increase awareness for industry and public	No information available	All PFASs	Yes	Whole life cycle	Dialogue	Yes?	None

	Action	Path Taken	BEPs Implemented[i]	Category of PFASss addressed	Articles covered?	Life cycle stage(s) addressed	Method of approach	Public-private partnership encouraged?	Level of constraint
	public. Link to 2009 informational document[20] Link to 2013 informational document[21]								
Germany	Threshold and guide values for different media, e.g. drinking water and sludge	Manage exposure	Water management, off-gas and solid waste management	Perfluoroalkyl Carboxylic and Sulfonic acids	No	Product use; Product disposal	Regulatory	No	Water treatment measures Monitoring
Japan	PFOS and its salts listed as Class I Specified Chemical Substances under the Chemical Substances Control Law (CSCL) Link to law[22]	Manage the manufacture, import, export and use	Minimize the use of PFOS	PFOS and its salts	yes	Manufacture, import, export, use	Regulatory	No	Strict regulations on manufacture, use, export and import Reporting to the PRTR

20 See, http://www.umweltbundesamt.de/sites/default/files/medien/publikation/long/3818.pdf
21 See, http://www.umweltbundesamt.de/publikationen/guide-environmentally-responsible-use-of
22 See, http://www.cirs-reach.com/Japan_CSCL/New_Japan_Chemical_Substances_Control_Law_CSCL.html

	Action	Path Taken	BEPs Implemented[i]	Category of PFASss addressed	Articles covered?	Life cycle stage(s) addressed	Method of approach	Public-private partnership encouraged?	Level of constraint
	PFOS and its salts are subject to the export restriction under the Foreign Exchange and Foreign Trade Law								system and SDS system
Netherlands	*See EU actions*								
Norway	Monitoring and screening of PFASs in the environment Links to monitoring studies Urban terrestrial environment 2014[23], Urban fjord 2014[24], Milkys 2012[25],	Continuous monitoring	Not relevant	Varies from year to year	Not relevant	Discharges from all life cycles are addressed	Analysis	No	None

23 See, http://www.miljodirektoratet.no/Documents/publikasjoner/M261/M-261.pdf
24 See, http://www.miljodirektoratet.no/Documents/publikasjoner/M205/M205.pdf
25 See, http://www.miljodirektoratet.no/Documents/publikasjoner/M69/M69.pdf

	Action	Path Taken	BEPs Implemented[i]	Category of PFASss addressed	Articles covered?	Life cycle stage(s) addressed	Method of approach	Public-private partnership encouraged?	Level of constraint
	Milkys 2013[26], Lakes in Norway 2013[27], Screening data 3025/2013 Contaminants in air and precipitation 2013[28]								
Norway	Discharge permits for waste treatment plants (WTP)	WTP must apply for permission to discharge selected PFASs	Under development	Primarily PFOS, PFOA, C9-C14 PFCA.	Not relevant	End of life-stage	Regulatory	No	WTP must screen and report levels of PFASs in their discharges, and must apply for permission for discharges.
Norway	Monitoring and clean-up of PFAS polluted soil at airport fire drill	Airports must monitor levels of PFAS at their fire drill sites and propose	Under development	PFOS and other relevant PFASs from AFFF	No	End use	Regulatory	No	Airports must screen and report levels of PFASs in their soil, and must propose

26 See, http://www.miljodirektoratet.no/Documents/publikasjoner/M250/M250.pdf
27 See, http://www.miljodirektoratet.no/Documents/publikasjoner/M157/m157.pdf
28 See, http://www.miljodirektoratet.no/no/Publikasjoner/2014/Desember-2014/Monitoring-of-environmental-contaminants-in-air-and-precipitation-annual-report-2013/

	Action	Path Taken	BEPs Implemented[i]	Category of PFASss addressed	Articles covered?	Life cycle stage(s) addressed	Method of approach	Public-private partnership encouraged?	Level of constraint
	sites Link to presentation, 2014[29] Link to PFAS at fire drill sites, 2008[30]	measures to reduce pollution							measures to reduce pollution.
Norway	Follow-up of the PFOS regulation under the Stockholm Convention, with an aim to minimize exemptions.	Continuous assessment of the necessity of exemptions from the PFOS ban in the Stockholm Convention	Guidelines implemented for acceptable purpose applications under the Stockholm Convention	PFOS and PFOS related substances	Yes	All	Regulatory	No	Fewer exemptions
Norway	Ban on manufacture, production, import and retail of consumer products containing PFOA (as of June 2014)	Ban	Not relevant	PFOA and some closely related substances	Yes	All except waste	Regulatory	No	Ban

29 See, http://www.miljodirektoratet.no/Documents/publikasjoner/M-40/M40.pdf
30 See, http://www.miljodirektoratet.no/old/klif/publikasjoner/2444/ta2444.pdf

	Action	Path Taken	BEPs Implemented[i]	Category of PFASss addressed	Articles covered?	Life cycle stage(s) addressed	Method of approach	Public-private partnership encouraged?	Level of constraint
Norway	Analysis of PFAS in products Links to studies: PFAS in fire fighting foam[31] PFOA in Norway, 2007[32] PFCs in consumer products, 2009[33] PFAS in outdoor textiles and gear, 2015[34] Analysis of per- and polyfluorinated substances in articles, Nordic working paper, 2015[35]	Compliance check and monitoring	Minimization of PFASs used	Compounds subject to national regulation and other PFAS	Yes	Use in products	Enforcement, monitoring	No	Enforcement

31 See, http://www.miljodirektoratet.no/no/Publikasjoner/Publikasjoner/2012/September Inventory_of_PFOS_and_PFOS_related_substances_in_fire_fighting_foams_in_Norway/

32 See, http://www.miljodirektoratet.no/old/klif/publikasjoner/2578/ta2578.pdf

33 See, http://www.miljodirektoratet.no/no/Publikasjoner/2014/Desember-2014/Monitoring-of-environmental-contaminants-in-air-and-precipitation-annual-report-2013/

34 See, http://www.miljodirektoratet.no/no/Publikasjoner/2015/Januar1/Investigation-of-outdoor-textiles-and-gear-with-respect-todetermine-the-content-of-ionic-perfluorinated-substances-PFASs/

35 See, http://www.miljodirektoratet.no/Documents/publikasjoner/M360/M360.pdf

	Action	Path Taken	BEPs Implemented[i]	Category of PFASss addressed	Articles covered?	Life cycle stage(s) addressed	Method of approach	Public-private partnership encouraged?	Level of constraint
Norway	Listing of PFOS, PFOA and C_9-C_{14} perfluorinated carboxylic acids on the national priority list	Political target to reduce the use and emissions of compounds on the priority list	Minimization of PFASs used	PFOS, PFOA and C_9-C_{14} perfluorinated carboxylic acids	Yes	All, including waste	Policy	No	Political
People's Republic of China	Monitoring of PFASs production and emission	Continuous monitoring	Not relevant	PFOS and PFOA	No	N/A	Monitoring	No	None
People's Republic of China	Ban of production, transportation, application, imports and exports of PFOS, its salts and PFOSF, except for specific exemptions and acceptable use (2014) Link to the	Ban	Minimisation of PFASs used	PFOS, its salts and PFOSF	-	Manufacture, use, sale, and import	Regulatory	-	Ban

	Action	Path Taken	BEPs Implemented[i]	Category of PFASss addressed	Articles covered?	Life cycle stage(s) addressed	Method of approach	Public-private partnership encouraged?	Level of constraint
	Announcement[36]								
People's Republic of China	Restriction of the production of PFOS and PFOA and support of R&D for alternatives to these substances (2011) Link to the Guide[37]	Restriction included as part of the National Development and Reform Commission, which issues an Industrial Reconstructing Guide Directory	Restriction of use	PFOS and PFOA	-	-	-	No	

36 See, http://www.zhb.gov.cn/gkml/hbb/bgg/201404/t20140401_270007.htm
37 See, http://www.gov.cn/flfg/2011-04/26/content_1852729.htm

	Action	Path Taken	BEPs Implemented[i]	Category of PFASss addressed	Articles covered?	Life cycle stage(s) addressed	Method of approach	Public-private partnership encouraged?	Level of constraint
People's Republic of China	Substances listed under the High Pollution, High Environmental Risk Product Catalogue (as of 2008) Link to the list[38]	Political target to establish financial end environmental protection priorities	Minimization of the PFASs used	High temperature melting membrane fluorine resin coating/ PFOA	Yes	-	Policy	No	
Poland	HELCOM Baltic Sea Action Plan (2007) restricts use and encourages substitution in Baltic Sea area. Link to HELCOM[39]	Manage use	No information available	PFOA and PFOS	No information available	No information available	Regulatory		No information available
Poland	Control of Hazardous Substances in the Baltic Sea Region (COHIBA) 2009-2012, assessed	Manage use and disposal	No information available	PFOS and PFOA	No	Waste	Voluntary	Yes	None

38 See, http://www.zhb.gov.cn/gkml/hbb/qt/200910/t20091023_180136.htm
39 See, http://helcom.fi/baltic-sea-action-plan

	Action	Path Taken	BEPs Implemented[i]	Category of PFASss addressed	Articles covered?	Life cycle stage(s) addressed	Method of approach	Public-private partnership encouraged?	Level of constraint
	pollution in Baltic Sea and developed management options and contribute to development of national implementation plans. Link to COHIBA[40]								
Poland	National Implementation Plan of Baltic Sea Action Plan (2013) extends routine monitoring of PFOS in marine waters.	Monitoring	No information available	PFOS	No	N/A	Monitoring	No information available	None
Republic of Korea	Under the Persistent Organic Pollutions Control Act, PFOS, its salts, PFOS-F are designated as restricted	Restriction on manufacture, import, export, use	Minimize their uses with the efforts to develop alternatives	PFOS, its salts and PFOS-F	Yes	Manufacture, import, export, use	Regulatory	Yes	Strict restriction on manufacture, import, export, use except acceptable uses and specific

40 See, http://www.cohiba-project.net/

	Action	Path Taken	BEPs Implemented[i]	Category of PFASss addressed	Articles covered?	Life cycle stage(s) addressed	Method of approach	Public-private partnership encouraged?	Level of constraint
	substances								exemptions in the Stockholm Convention
Russia	Regulation of APFO in occupational air. Other short- and middle-chain PFASs are regulated in occupational air and water.	Manage occupational exposure	Occupational health and safety measures	APFO and short- and middle-chain PFASs.	No	Chemical manufacture; Product manufacture	Regulatory	No information available	Compliance measure
Sweden	Analysis of PFAS in fire-fighting foams	Monitoring	Not relevant	Both target (19 different PFASs) and non-target screening analysis	Yes	Use in products	Analysis	No	None
Sweden	Development of a national action plan for PFAS	Political target to reduce the use and emissions that will lead to exposure to humans via drinking water. Increase knowledge for	Not relevant	All PFASs	Yes	Whole life cycle	Voluntary, Regulatory	Yes	Potentially regulations and/or voluntary agreements

	Action	Path Taken	BEPs Implemented[i]	Category of PFASss addressed	Articles covered?	Life cycle stage(s) addressed	Method of approach	Public-private partnership encouraged?	Level of constraint
		PFASs							
Sweden	Investigating and if needed suggest national and/or EU regulations and other measurements, specifically for fire-fighting foams	Manage the manufacture, sale, import and export	Not relevant	All PFASs	Yes	Use in products and articles	Voluntary and regulatory	Yes	Potentially regulations and/or voluntary agreements
Sweden	Mapping of uses and applications of PFAs and the alternatives on the market	Literature survey	Not relevant	All PFASs	Yes	Use in products and articles	Literature survey	No	None
Sweden	Action value for drinking water	Manage exposure	Water management	Sum of seven PFAS (PFOA, PFHpA, PFHxA, PFPeA, PFOS, PFHxS, PFBS)	No	Product use?	Regulatory	No	Water treatment measures Monitoring

	Action	Path Taken	BEPs Implemented[i]	Category of PFASss addressed	Articles covered?	Life cycle stage(s) addressed	Method of approach	Public-private partnership encouraged?	Level of constraint
Sweden	Collection of analytical data of PFAS in drinking water from Swedish municipalities	Risk assessments	-	All PFASs	-	Discharges from all life cycles are addressed	Voluntary	Yes	Voluntary agreements Monitoring
Sweden	Monitoring and screening of PFASs in the environment	Continuous monitoring	Not relevant	-	No	Discharges from all life cycles are addressed	Analysis	No	Monitoring
Sweden	Development of preliminary guideline values for PFAS in soil and groundwater	-	Not relevant	-	No	Discharges from all life cycles are addressed	Analysis	No	Basis for the preparation of general guidelines regarding remediation of PFAS-contaminated areas.
Sweden	Proposal for Environmental Quality Standard level for PFOS in groundwater body	-	-	PFOS	-	-	Regulatory	-	-

	Action	Path Taken	BEPs Implemented[i]	Category of PFASss addressed	Articles covered?	Life cycle stage(s) addressed	Method of approach	Public-private partnership encouraged?	Level of constraint
Sweden	Follow-up of the PFOS regulation under the Stockholm Convention, with an aim to minimize exemptions.	Continuous assessment of the necessity of exemptions from the PFOS ban in the Stockholm Convention	Yes, as far as possible	PFOS and PFOS related substances	Yes	All	Regulatory	No	Fewer exemptions
United Kingdom	*See EU actions*								
United States	2010/15 PFOA Stewardship Program; work toward elimination of long-chain PFCAs and related substances from emissions and products by end of 2015	Encourage industry phaseout	Emission controls and product content	Long-chain perfluorocarboxylic acids and related substances	Yes	Chemical manufacture; product manufacture	Voluntary	Yes	Annual reporting obligations for companies
United States	Significant New Use Rule (SNUR) designates manufacture (including import) or processing of long-chain perfluoroalkyl	Manage manufacture, import, and processing	Minimization of perfluoroalkyl sulfonates used	Perfluoroalkyl sulfonates (PFSAs)	No	Chemical manufacture and import; processing of chemicals	Regulatory	No	Notification requirements prior to manufacturing, importing, or processing

	Action	Path Taken	BEPs Implemented[i]	Category of PFASss addressed	Articles covered?	Life cycle stage(s) addressed	Method of approach	Public-private partnership encouraged?	Level of constraint
	sulfonates for any use as a significant new use, except for few ongoing uses (40 CFR §721.9582)								
United States	Significant New Use Rule (SNUR) designates manufacture (including import) or processing of perfluoroalkyl carboxylate chemical for use as part of carpets or to treat carpets (e.g., for use in the carpet aftercare market) as a significant new use, except for few ongoing uses (40 CFR § 721.10536)	Manage manufacture, import, and processing	Minimization of perfluoroalkyl carboxylate chemicals used	Perfluoroalkyl carboxylate chemicals	Yes	Chemical manufacture and import; processing of chemicals; articles	Regulatory	No	Notification requirements prior to manufacturing, importing, or processing
United States	Proposed Significant New Use Rule (SNUR) to designate import of perfluoroalkyl carboxylate	Manage manufacture, import, and processing	Minimization of perfluoroalkyl carboxylate chemicals used	Perfluoroalkyl carboxylate chemicals	Yes	Chemical manufacture and import; processing of chemicals; articles	Regulatory	No	Notification requirements prior to manufacturing, importing, or processing

	Action	Path Taken	BEPs Implemented[i]	Category of PFASss addressed	Articles covered?	Life cycle stage(s) addressed	Method of approach	Public-private partnership encouraged?	Level of constraint
	chemicals, including in products, and domestic production or processing of these chemicals as a significant new use, except for few ongoing uses (Proposed rule; 80 FR 2885) Link to SNUR[41]								

i 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. Revised March 2014.

41 See, http://www.zhb.gov.cn/gkml/hbb/bgg/201404/t20140401_270007.htm

VOLUNTARY RISK REDUCTION MEASURES TAKEN BY CORPORATIONS

In addition to the risk reduction measures by jurisdictions summarized in Table 3, voluntary programs by either PFAS manufacturers or by PFAS users, sometimes sponsored by authorities, have been implemented successfully.

Voluntary Risk Reduction Measures by PFAS Manufacturers:

In 2000, as a result of negotiations between the U.S. EPA and 3M, the company announced “that it will voluntarily phase out and find substitutes for perfluorooctanyl sulfonate (PFOS) chemistry” (EPA, 2000). 3M was the only US manufacturer of PFOS and ceased manufacturing of PFOS and the related compounds by the end of 2002.

In 2006, the US EPA invited major fluoropolymer and fluorotelomer manufacturers to join in a global stewardship program with two goals (US EPA, 2015):

- To achieve a 95 percent reduction, measured from a year 2000 baseline, in both facility emissions to all media of PFOA, precursor chemicals that can break down to PFOA, and related higher homologue chemicals, and product content levels of these chemicals by the end of 2010, and;
- To commit to working toward the elimination of these chemicals from emissions and products by the end of 2015.
- In 2006 eight companies (i.e., Arkema, Asahi, BASF Corp.(successor to Ciba), Clariant (now Archroma), Daikin, 3M/Dyneon, DuPont, Solvay Solexis (now Solvay Specialty Polymers)) committed to the 2010/2015 PFOA Stewardship Program. In addition, the participating companies also agreed to submit annual progress reports, to work cooperatively with EPA and to establish scientifically credible analytical standards and laboratory methods to ensure comparability of reporting (US EPA, 2015).

Furthermore, the U.S. fluoropolymer manufacturers, known as the Fluoropolymers Manufacturing Group, committed to and achieved a 90% reduction of PFOA content in their worldwide dispersion products by 2007.

The annual progress reports for 2013 achievements were published on U.S EPA's website in January 2015 and show that several of the participating companies have already fulfilled their 2015 commitments or are on track to reach the 2015 goal (US EPA, 2015).

In 2010, the "Environmental Performance Agreement Respecting Perfluorocarboxylic Acids (PFCAs) and their Precursors in Perfluorinated Products Sold in Canada" (Environment Canada, 2010) was signed between Environment Canada, Health Canada and four companies - Arkema Canada Inc., Asahi Glass Company Ltd., Clariant Canada Inc., and E.I. DuPont Canada Company – and is in effect until December 31, 2015. The agreement is a key component of Canada's comprehensive risk management strategy for PFCAs. "The participating companies voluntarily commit to: 1. Reducing by 95% the product content levels of residual PFOA, long-chain PFCAs and their precursors in their perfluorochemical products sold in Canada by December 31, 2010; 2. Working towards eliminating the remaining 5% of these substances in the products by December 31, 2015; and 3. Reporting annually to Environment Canada information on the residual and non-residual (i.e., active ingredient) content of their perfluorochemical products sold in Canada."

The annual progress report summaries can be found on Environment Canada's website (Environment Canada, 2010). The most recent achievements (posted for 2012) demonstrate that all but one company report reductions of 97% or greater for "Total Quantity of Residual PFOA, Long-Chain PFCAs, and Precursors Measured Against Baseline Year".

Voluntary Risk Reduction Measures by PFAS Users

Although PFASs are used in many different industries, only the semiconductor industry and the apparel and footwear sector publicly implemented voluntary approaches to limit or ban certain long-chain PFASs from their supply chain.[42]

- In 2006, the World Semiconductor Council (WSC), an industry association of regional and country semiconductor industry associations, committed to "ending all non-critical uses of PFOS and"to

42 Please note, individual companies might have made such commitments but collecting such information was outside the scope of this report. Additionally, some industry sectors (for example, the carpet and paper industry in the USA) transitioned to using short-chain alternatives without public commitments. The carpet industry transitioned in the 2008 timeframe whereas the paper industry transitioned in the 2010 timeframe).

"work to identify substitutes for PFOS in essential uses for which no other materials are presently available" (WSC, 2006). In 2007, the WSC reported elimination of non-critical PFOS uses in Europe, Japan, Korea and Chinese Taipei (WSC, 2007). In 2011, the last year the WSC reported in detail on this voluntary effort (WSC, 2011) elimination of non-critical PFOS uses had been completed, the PFOS use for some critical applications continued and the overall global PFOS emissions had been reduced by 99% when compared to a 2005 baseline. In addition, the report states the following: "… manufacturers who synthesize and supply PFOS to the photolithography chemical suppliers have terminated production of these PFOS materials. The WSC SC manufacturers have agreed not to seek new uses of photolithography chemicals containing PFOS and the suppliers have publicly stated that they will not provide PFOS-containing chemicals for any new uses."

- The AFIRM Group (Apparel & Footwear International RSL Management Group) which was founded in 2004 by adidas, C&A, Gap, Levi Strauss & Co., Nike and Marks & Spencer list the restriction of PFOS and PFOA in their "2011 AFIRM Supplier Toolkit" (AFIRM, 2011). It is unclear whether or not the restriction was in-place in earlier versions of their supplier tool kit. Current members in the AFIRM Group include Adidas Group, Asics, Bestseller, Carhartt, Esprit, Gap, Gymboree, H&M, Hugo Boss, J. Crew, Lacoste, Levi Strauss & Co., New Balance, Nike, Pentland, Puma, PVH, S. Oliver, and VF Corp.

- The apparel and footwear trade group Zero Discharge of Hazardous Chemicals (ZDHC) which was founded in 2011 and now has 18 signatory brands (adidas Group, Burberry, C&A, United Colors of Benetton, Esprit, G-Star Raw, Gap Co., H&M, Inditex, Jack Wolfskin, Lbrands, Levi Strauss & Co., Li Ning, Marks & Spencer, New Balance, Nike, Puma, PVH) published their Manufacturer Restricted Substances List (MRSL) in 2014 (ZDHC, 2014). It lists the following commitment: "Beginning January 1, 2015, the members are banning the intentional use of durable water, oil and stain repellent finishes and soil release finishes (fluorinated polymers) based on long-chain technology". The ZDHC group has adopted OECD's definition of long-chain and short-chain PFAS.

- bluesign® system is a company that works with chemical suppliers, textile manufacturers and brands to improve and implement best practices in their supply chain. The company developed a positive list of approved chemicals called bluesign® bluefinder. As of January 1, 2015 all long-chain fluorinated durable water, oil, and stain repellent chemicals have been removed from the bluesign® bluefinder (bluesign®, 2015; bluesign® 2012). According to information on the company's website (accessed on April 30, 2015), bluesign® lists more than 20 brands, ca. 100 manufacturers, and more than 50 chemical suppliers as members.

COMMONALITIES BETWEEN RISK REDUCTION APPROACHES FOR PFAS ACROSS JURISDICTIONS

This section identifies common themes in developing and implementing risk reduction approaches for certain PFASs. This analysis is primarily based on the information provided by the surveyed delegations and identifies the (1) framework conditions needed to develop and implement risk reduction approaches; (2) the strengths of existing approaches; and (3) challenges faced during their development, implementation, and enforcement. The information in this section is not intended to be exhaustive. Rather it is to inform countries about the options for risk management.

Framework Conditions for the Development and Implementation of the Risk Reduction Approaches

This section addresses framework conditions – i.e., the factors and concerns that prompted the development and/or implementation of risk reduction approaches. The following framework conditions were identified through a comparative analysis of risk reduction approaches across the studied delegations. In all delegations with in-place risk reduction approaches, PFASs were being manufactured and/or imported as a neat chemical or as part of an article at the time the approach(es) were developed.

Demonstrated human health and environmental risk. The majority of surveyed delegations chose to prioritize certain long-chain PFASs for risk reduction based on a growing scientific knowledge base of their potential for toxicity in humans and in animals, persistent and bioaccumulative properties, and ability to undergo long-range transport. These concerns are supported by toxicological studies on animals indicating that certain long-chain PFASs elicit developmental and systemic toxicity, as well as carcinogenic effects. Other concerns that prompted risk reduction activities among surveyed delegations include monitoring data that show the presence of certain long-chain PFASs in remote areas as well as in cord blood and breast milk, and the ubiquitous use of certain long-chain PFASs in industrial and consumer applications. Focus on direct emission sources was included in these approaches as well.

Commitment to risk reduction at international level. The listing of PFOS and related compounds under Annex B of the Stockholm Convention for POPs in 2009, as well as other international initiatives on certain long-chain PFASs, led many delegations to take domestic measures to reduce risks. It was expressed that these international efforts may be the most important driving force in the implementation of risk reduction approaches for certain PFASs by some nations. Collaboration among country governments and organisations also helps to exchange information on risk reduction strategies that can help prioritise or inform action by others. For example, the US EPA's voluntary 2010/2015 PFOA Stewardship Program was implemented three years before the Stockholm Convention PFOS listing and may have encouraged some nations to start prioritizing PFC risk reduction actions. However, those countries with signatory obligations under the Convention were more strongly motivated to develop and implement regulatory measures after the listing of the PFOS and related substances as persistent organic pollutants. The voluntary measures by industry have also demonstrated that such actions can be faster implemented than regulations by delegations. However, voluntary actions might not include commitments from all participants globally. Regulations provide a level playing field.

Box 3. US EPA Enforceable Consent Agreement

In 2003, US EPA negotiated an Enforceable Consent Agreement (ECA) with industry and interested parties requiring certain signing parties to generate and submit data. This ECA sought to collect fluoropolymer incineration testing data on to help determine if these substances break down and release PFOA when disposed of in municipal incinerators. The goal of creating the ECA was to identify and generate additional information to strengthen the PFOA draft risk assessment. More information on the ECA is available at: http://www.epa.gov/opptintr/pfoa/pubs/eca.html.

Consideration of voluntary and regulatory approaches. The type of risk reduction approaches implemented across delegations has varied. Australia implemented voluntary actions for existing long-chain PFASs because they enabled quick and effective action, and a regulatory action for new PFASs to make toxicity data requirements for pre-market entry applications more stringent. Canada chose to implement a voluntary risk reduction approach during the early risk management stages, which allowed the country to simultaneously conduct a risk assessment to be used to inform regulatory risk reduction strategies. As described above, the US EPA implemented the voluntary 2010/2015 Stewardship Program. The EU noted that it sought to implement regulatory measures to ensure a level playing field in the EU market. Several delegations find that regulatory actions are the most efficient approach as they enable the enforcement of measures and they found that they probably take less time than negotiating a voluntary agreement. Japan noted that regulatory approaches provide the best way to comply with obligations under the Stockholm Convention. The majority of surveyed delegations have implemented voluntary and regulatory PFAS risk reduction approaches to complement each other.

Consultation with industry and other stakeholders. Several surveyed delegations noted the importance of multi-stakeholder participation to inform the development and implementation of risk reduction strategies. Governments have played the primary role in developing and implementing PFAS risk reduction approaches across the surveyed delegations and have thus been responsible for convening stakeholders. Industry has helped to provide valuable research and monitoring data on PFASs and developed alternatives. Industry's participation in voluntary approaches has also helped to establish realistic phase-out timelines, reduction targets, and reporting and accountability frameworks, often reaching goals ahead of regulations. Advocacy groups have helped to incite action by voicing concerns about the health and environmental effects of PFASs, and the research community has provided necessary scientific data on which to base prospective risk reduction approaches.

Use of scientific and/or economic assessments. The consideration of hazard, exposure, and/or risk is an important framework condition in the development of risk reduction approaches to PFASs. Many countries require that regulatory approaches be supported by risk assessment demonstrating need to reduce risk and exposure. Some also require that a socio-economic or cost-benefit analysis be conducted. While many countries have conducted their own analyses on PFASs, others indicated their use of published assessments from their international counterparts to save resources and avoid duplication of efforts.

The development of hazard and exposure assessments requires the collection of data from industry and researchers. One strategy for collecting data is through the development of a negotiated yet enforceable agreement between government, industry, and interested parties as was done in the US (See Box 3). Another approach, such as that used by Canada, is to use documented toxicity and exposure concerns to form the basis for early risk management strategies, and then use full risk assessments to inform regulatory strategies. The collection of environmental monitoring data of PFASs, such as done by the Japanese and other governments, also helps inform risk assessment; the evaluation of production, import, and use volumes is also useful and is carried out in some form by the majority of surveyed delegations.

Consideration of alternatives. Jurisdictions surveyed considered alternative substances in the development of their risk reduction approaches, indicating its importance as a framework condition. Voluntary approaches consider alternatives inherently in their structure; their timelines and milestones for

Box 4. Monitoring PFOS and PFSA use in Australia

Australia's NICNAS conducted surveys to collect 2006 and 2007 import and use data on PFASs (specifically non-polymer PFFSAs) after alerts had been issued for six years. This included quantities imported or manufactured in Australia and uses of these products/mixtures. Data were also collected on essential uses of these substances and efforts towards finding safer alternatives. A comparison of the current findings with the results of the previous surveys to observe patterns of change in import and use of PFASs in Australia was also conducted.

Data obtained through this survey indicated an overall increase in PFSA and PFOS imports in Australia compared to previous years, although there were substantial changes in the type of imports and the use patterns. The bulk of the PFSA products imported contained perfluorobutanesulfonate (PFBS). The use of PFOS in Australia was mainly limited to critical uses, i.e., industries where no suitable alternatives are available, and most PFOS stocks were held for emergency use only.

The survey also gave insight into the types of alternatives being phased-in. Results indicated a move towards telomers and shorter chain length fluorinated sulphonates (mainly C4 and C6 chain lengths) or perfluorobutane sulfonic acid (PFBS) in aqueous film-forming foams (AFFF) .

PFOS continues to be used for chrome plating operations, in the photographic industry and there remain significant fire-fighting foam stockpiles containing PFOS, largely in major hazard facilities. Some firefighting sectors continue to use perfluorinated foams. One sector has taken a pro-active approach to eliminate use of fire-fighting foam containing PFASs. ASA had been using PFAS based fire-fighting foams (AFFF) from approx. 1983 to 2010. The early generation of AFFF used is understood to have contained PFOS and other predominantly long carbon chain perfluorinated compounds.

phase-out give industry the opportunity to develop alternatives that did not exist prior to the launch of the program. Regulatory approaches also promote the use of alternatives. For one, the regulatory process in most jurisdictions includes engagement with stakeholders and technical experts to determine the viability and commercial availability of alternatives when assessing the feasibility of an approach. Additionally, the availability of alternatives is often considered when conducting a cost-benefit analysis for a proposed regulatory action. Regulatory approaches also factor in a phase-out time to allow industry to transition to alternatives on a feasible timeline and often grant exemptions or an extended phase-out timeline for applications of specific PFASs where alternatives are not yet technically and economically viable. This is demonstrated in the Stockholm Convention through the Acceptable Purpose and Specific Exemption determination of PFOS and its related compounds (see Box 2).

Strengths of the Measures and Benefits Gained from Implementation

This section identifies strengths of risk reduction measures, as well as any realized benefits, based on responses from surveyed delegations.

Benefits measurement. Many delegations evaluate the success of their strategies both qualitatively and quantitatively. The importance of doing so is evident in the structure of voluntary programs, which have milestones and reporting requirements built into their negotiated agreements; this facilitates the annual assessment of benefits.). The data received for the Canadian and US voluntary programs indicate that significant progress has been made in reaching the interim targets set out in the agreement sand that the signatory companies are on track to meet their commitments.

Delegations commonly measure the success of risk reduction approaches by tracking emissions levels and production and use information in their country (see Box 4). For example, Norway conducts periodic measurements of PFOA, PFOS, and other perfluorinated compounds in consumer products as well as during company inspections to monitor compliance with the nation's ban of these substances. However, some delegations commented that since these substances are subject to long-range transportation there are technical difficulties related to linking any increases/decreases in environmental media to domestic risk management actions and the levels in the environment may be the result of activities with the substances in other jurisdictions.

The government, research and academic community also contribute to the evaluation of PFAS risk reduction successes by conducting studies measuring their levels in the environment and in humans over time, such as conducted in the US by the CDC (for human data) and by the EPA (for drinking water). Other qualitative successes cited by one delegation include increased awareness of the risks associated with PFASs among industry, NGOs, and the public, as well as the development of technical expertise during the development of and transition to non-fluorinated alternatives.

Voluntary Approaches as Effective Measures: The voluntary risk reduction approaches taken by corporations have been effective measures to reduce emissions from manufacturing facilities and from product content. Such approaches need to be followed quickly by effective regulations to level the playing field. Successful stakeholder engagement when designing such approaches could serve as examples for any such programmes in the future.

Level of constraint on manufacturers, importers, and exporters. The most common level of constraint in voluntary approaches is the required annual reporting from entities bound to the agreement. In regulatory situations, constraint is typically characterized by enforcement and compliance measures. This may include a ban or restriction of the manufacture, use, sale, offer for sale, and/or import of particular PFASs that are subject to enforcement. Regulatory approaches may also require compliance through mandatory notifications laid out under the regulation. For example, manufacturers or users of PFASs are often required to notify the regulating body should changes in use, volume, and the availability of any new information that pertains to the risk assessment of the chemical.

CHALLENGES FACED DURING DEVELOPMENT AND IMPLEMENTATION OF THE RISK REDUCTION MEASURES

This section summarises the key challenges across surveyed delegations in developing and implementing risk reduction measures.

Availability of robust scientific data during development. A lack of robust and readily available scientific information poses an issue when developing PFAS risk reduction approaches because it limits the quality of the risk assessment. Examples of data that are needed but are often not fully characterized include sources and pathways of exposure, detection and measurement, fate and transport, and a comprehensive evaluation of the effects of the classes of PFASs evaluated on human health and the environment. These data gaps are especially a challenge when they exist for alternatives. For example, one delegation noted that data are currently limited on the long-term effects of short-chain PFAS degradation products that are increasingly being used as replacements for long-chain PFASs. Although data on human health effects indicate a reduced hazard profile, uncertainty exists surrounding their long-term effects in the environment. A report by the Nordic Council of Ministers, 2013, concluded that there are considerable information and knowledge gaps regarding PFASs, other than PFOA and PFOS and a number of delegations cited information gaps as a key challenge in managing PFASs.

Tracking emissions data. Another key issue with the development of PFAS risk reduction approaches is the volume of substances that fit within the PFAS chemical class. There are hundreds of different types of PFASs, all of which have unique uses and physicochemical properties, and it is difficult to track emissions data for all of them. However, some data exist for PFOS (Paul et al., 2009) and for short-chain and long-chain PFCAs, PFOA and PFO (perfluoroctanoate) (Prevedouros et al., 2006; Wang et al., 2014; Armitage et al., 2009; OECD 2005, 2006, 2011, 2015). Emissions data were made available through the voluntary initiatives such as the US EPA stewardship program (which provides global data) and the Canada Environmental Performance Agreement. The challenge for those programs is to get all of industry to participate

Voluntary Risk Reduction Measures Taken by Corporations: All voluntary approaches face the challenge that only a fraction of the entire industry participates. Therefore, such efforts need to be closely followed by effective regulations

Determining extent of use in the supply chain. A challenge faced in the development of risk reduction approaches is the ability to get all of the necessary information on the extent of a substances use. For example, when one delegation was considering a PFOA ban, it was faced with a lack of information on PFOA and PFOA-related substances use in the supply chain. These data were needed to develop limit values and a reasonable implementation timeline. In many cases, importers of products did not have the information to manage the chemical constituents in their products, making this information collection challenging. Surveys and public comment periods are the beneficial tools that help fill data gaps.

Implementation changes in industrial procedures. The implementation of PFAS risk reduction approaches can be difficult for industry. Alternatives need to be available and approved by regulatory bodies for use, economically cost-effective and technically suitable. When specific PFASs are phased out and their alternatives are implemented, adjustments in industrial processes often need to be undertaken by end users consuming time and creating a cost burden.

Technical challenges with enforcement. Once a PFAS risk reduction approach is developed and implemented, challenges may still arise in its ongoing enforcement. For example, one delegation recalled its experience with a lack of cost-effective and available technologies to dispose and/or destroy PFAS-contaminated materials at the volumes required. Challenges also exist in the ongoing monitoring of PFAS levels. Because of the wide range of PFAS substances and their varied use, there is a lack of analytical methods available to detect those substances that will be released in the environment or found in articles. Confounding the issue is that there is also a lack of knowledge of which substances or degradation products to look for in monitoring studies. There is a need for developing enhanced PFAS standards and measuring instruments. Issues with contaminations and detection levels have also made it difficult to monitor PFAS target reductions. Some delegations expressed that industry and researchers have played a key role in overcoming some of these technical challenges.

Complexity of articles containing PFASs. As seen in Table 3, variation exists among the risk reduction approaches regarding articles. Some approaches consider articles while others only target PFASs substances or mixtures.

Delegations cite several challenges in addressing articles. For one, it is difficult to identify chemicals in articles if their ingredients are not required to be labelled. When the components of an article are unknown, it is difficult to assess their risks and therefore manage them. It is also difficult to prohibit the importation of foreign-manufactured items from countries that have no risk reduction approaches in place. The ability to accurately measure PFASs in articles (as discussed above) has also influenced some countries to not consider articles in their risk reduction strategies at this time. Among delegations with risk reduction strategies that address articles, the lack of available information to aid in the setting of limit values and implementation deadlines was also cited as a challenge.

GOOD PRACTICES AND OPTIONS TO SUPPORT SHARED CHALLENGES IN THE DEVELOPMENT AND IMPLEMENTATION OF PFAS RISK REDUCTION APPROACHES

Several best practices emerged based on the analysis of responses from the surveyed delegations. The list below captures best practices related to the development and implementation of risk reduction approaches. It is intended to promote intergovernmental dialogue and information sharing on additional best practices.

- ***Risk reduction approaches should be science-based***. Risk reduction approaches should be based on sound science and reflect an understanding of the risks posed by the classes of PFASs evaluated. Hazard, exposure, and/or risk assessments are common requirements for regulatory actions, as well as cost-benefit and socio-economic assessments.

- R***isk reduction approaches should be developed in consultation with stakeholders***. Consultation helps ensure that the government and stakeholder community have a shared understanding of the risk posed by the classes of PFASs evaluated; the development and evaluation of alternatives; the market transition to alternatives; technological challenges in monitoring efforts; and other factors.

- ***A phased approach to risk reduction should be considered when scientific data are lacking***. A phased approach where early risk management actions are used to inform the development of further action, particularly when scientific data are lacking or more time is needed to prepare scientific or economic assessments to support regulatory action.

- ***International collaboration should be encouraged.*** Collaboration among jurisdictions is important to exchange information on scientific advancements, availability of safer alternatives, and lessons learned related to development and implementation of risk reduction strategies. Collaboration can also help minimize duplication of effort – e.g., delegations can use or build upon hazard assessments conducted by others.

- ***Quantitative benefits should be measured and communicated***. The tracking of emissions rates, production volume and use information, and levels of the classes of PFASs found in environmental media (e.g., in water and soil) and in humans (via biomonitoring data) are examples of quantitative metrics that enable delegations to monitor progress in reaching risk reduction goals. Quantitative metrics also enable clear communication on the benefits of risk reduction approaches to the stakeholder community.

- ***Timelines for action with ambitious targets should be established***. While compliance monitoring programs are typical of regulatory approaches, building milestones and reporting requirements into voluntary programs is important to facilitate benefits measurement.

REFERENCES

AFIRM (2011). AFIRM Supplier Toolkit http://www.afirm-group.com/wp-content/uploads/2013/11/AFIRMSupplierToolkit.pdf

Armitage J.M., M. MacLeod, I.T. Cousins, Environmental Science & Technology 43 (2009) 1134-1140

Bao J, Lee YL, Chen PC, Jin YH, Dong GH. (2014) Perfluoroalkyl acids in blood serum samples from children in Taiwan. Environmental Science and Pollution Research Jun; 21(12): 7650-7655.

bluesign®. (2012). Management of per-and polyfluoroalkyl substances (PFASs) according to bluesign® criteria. Retrieved on March 24, 2015, from http://www.bluesign.com/inc/template/FILES/PFAS_management_Nov2012.pdf

bluesign®. (2015). bluesign® brands. Retrieved from http://www.bluesign.com/industry/brands/references#.VRLoqvnFM

Buck, R. C., Franklin, J., Berger, U., Conder, J. M., Cousins, I. T., de Voogt, P., . . . van Leeuwen, S. P. J. (2011). Perfluoroalkyl and polyfluoroalkyl substances in the environment: Terminology, classification, and origins. *Integrated Environmental Assessment and Management*, 7(4), 513-541. doi: 10.1002/ieam.258

Chemical Watch. (2012). Clothing brands seek alternatives to long-chain PFCs. Retrieved March 24, 2015, from https://chemicalwatch.com/11701/clothingbrandsseekalternativestolongchainpfcs

Chang YJ, Chen WL, Bai FY, Chen PC, Wang GS, Chen CY. (2012) Determination of perfluorinated chemicals in food and drinking water using high-flow solid-phase extraction and ultra-high performance liquid chromatography/tandem mass spectrometry. Analytical and Bioanalytical Chemistry Jan; 402(3): 1315-1325.

Chimeddulam D, Wu KY. (2013) River water contaminated with perfluorinated compounds potentially posing the greatest risk to young children. Chemosphere ;90(5):1617-1624

Environment Canada (2006). Perfluorinated carboxylic acids (PFCAs) and precursors : an action plan for assessment and management. http://publications.gc.ca/site/eng/9.698956/publication.html

Environment Canada (2010). Environmental Performance Agreements and Results: Perfluorinated Carboxylic Acids (PFCAs) and their Precursors (2010-2015), from http://www.ec.gc.ca/epe-epa/default.asp?lang=En&n=0D8C879E-1#X-2013092511492112

Environment Canada (2013). Environmental Monitoring and Surveillance in Support of the Chemicals Management Plan-Perfluorooctane Sulfonate in the Canadian Environment. http://ec.gc.ca/toxiques-toxics/7331A46C-31C4-471B-A09E-EA9E18DD0810/1225_PFOS-FactSheet_e_v7-WEB.pdf

German Federal Environment Agency. (2009). Do without perfluorinated chemicals and prevent their discharge into the environment. http://www.umweltbundesamt.de/sites/default/files/medien/publikation/long/3818.pdf

German Federal Environment Agency, DFV and bvfa. (2013). Guide: Environmentally responsible use of fluorinated fire-fighting foams. http://www.umweltbundesamt.de/publikationen/guide-environmentally-responsible-use-of

Gewurtz et al (2013). Perfluoroalkyl acids in the Canadian environment: Multi-media assessment of current status and trends, Environment International Volume 59, Pages 183–200 http://www.sciencedirect.com/science/article/pii/S0160412013001098

Health Canada (2010). Report on Human Biomonitoring of Environmental Chemicals in Canada Results of the Canadian Health Measures Survey Cycle 1 (2007–2009). http://www.hc-sc.gc.ca/ewh-semt/pubs/contaminants/chms-ecms/index-eng.php

Health Canada (2013). Second Report on Human Biomonitoring of Environmental Chemicals in Canada. http://www.hc-sc.gc.ca/ewh-semt/pubs/contaminants/chms-ecms-cycle2/index-eng.php

Lien GW, Wen TW, Hsieh WS, Wu KY, Chen CY, Chen PC. (2011). Analysis of perfluorinated chemicals in umbilical cord blood by ultra-high performance liquid chromatography/ tandem mass spectrometry. Journal of Chromatography B 2011 Mar; 879(9-10): 641-646. PubMed

Lien GW, Huang CC, Wu KY, Chen MH, Lin CY, Chen CY, Hsieh WS, Chen PC. (2013). Neonatal-maternal factors and perfluoroalkyl substances in cord blood. Chemosphere Aug; 92(7): 843-850. PubMed

Lindstrom, A. B., Strynar, M. J., & Libelo, E. L. (2011). Polyfluorinated compounds: Past, present, and future. *Environmental Science and Technology*, 45(19), 7954-7961.

Nordic Council of Ministers. (2013). Per- and polyfluorinated substances in the Nordic Countries : Use, occurence and toxicology. http://norden.diva-portal.org/smash/record.jsf?pid=diva2%3A701876&dswid=3295

OECD. (2005). Results of Survey on Production and Use of PFOS, PFAS and PFOA, Related Substances and Products/ Mixtures Containging these Substances.

OECD. (2006). Results of the 2006 OECD Survey on Production and Use Of PFOS, PFAS, PFOA, PFCA, Their Related Substances and Products/Mixtures Containing These Substances.

OECD. (2011). PFCs: Outcome of the 2009 survey. Survey on the production, use and release of PFOS, PFAS, PFOA PFCA, their related substances and products/mixtures containing these substances.

OECD. (2013). OECD/UNEP Global PFC Group, Synthesis paper on per- and polyfluorinated chemicals (PFCs), Environment, Health and Safety Division, Environment Directorate, OECD, Paris.

OECD (2015). OECD/UNEP Global PFC Group, Working towards a global emission inventory of PFASs: Focus on PFCAs - status quo and the way forward, Environment, Health and Safety Division, Environment Directorate, OECD, Paris [Forthcoming].

OECD. (2015a). OECD Portal on Perfluorinated Chemicals: Home. Retrieved February 19, 2015, from http://www.oecd.org/ehs/pfc/

OECD. (2015b). OECD Portal on Perfluorinated Chemicals: Updates from International Organizations. Retrieved February 20, 2015, from http://www.oecd.org/ehs/pfc/updatesfrominternationalorganizations.htm

Paul A.G., K.C. Jones, A.J. Sweetman, Environmental Science & Technology 43 (2009)386-392.

Paul, A. G., Jones, K. C., & Sweetman, A. J. (2008). A First Global Production, Emission, And Environmental Inventory For Perfluorooctane Sulfonate. Environmental Science & Technology, 43(2), 386-392. doi: 10.1021/es802216n

Prevedouros K., I.T. Cousins, R.C. Buck and S.H. Korzeniowski; Environmental Science & technology 40 (2006) 32-44

Santoro, M. A. (2008). Brief History of Perfluorochemical Production, Products and Environmental Presence. ASTSWMO Mid-Year Meeting. April 23-24, 2008.

Swedish Chemicals Inspectorate. (2005). An Economic Impact Assessment of Regulation of PFOS in LRTAP.

Tittlemier A, Pepper K, Edwards L (2006). Concentrations of Perfluorooctanesulfonamides in Canadian Total Diet Study Composite Food Samples Collected between 1992 and 2004. Journal of Agricultural and Food Chemistry, 54, 8385-8369.

Toms et al. (2014), Perfluorooctane sulfonate and perfluorooctanoate serum concentrations in an Australian population from 2002 to 201, Environment International, 71 (2014) 74–80

US EPA (United States Environmental Protection Agency) (2000). EPA and 3M Announce Phase Out of PFOS. Retrieved February 19, 2015, from http://yosemite.epa.gov/opa/admpress.nsf/0/33aa946e6cb11f35852568e1005246b4

US EPA. (2009). *Long-Chaing PFCs Action Plan*, see http://www.epa.gov/oppt/existingchemicals/pubs/pfcs_action_plan1230_09.pdf

US EPA. (2014). Perfluorooctanoic Acid (PFOA) and Fluorinated Telomers. 2014 Annual Progress Reports. http://www.epa.gov/opptintr/pfoa/pubs/stewardship/preports8.html

US EPA. (2015). 2010/2015 PFOA Stewardship Program. Retrieved February 19, 2015, from http://www.epa.gov/opptintr/pfoa/pubs/stewardship/

UNEP. (2009a). Report of the Conference of the Parties of the Stockholm Convention on Persistent Organic Pollutants on the work of its fourth meeting.

UNEP. (2009b). Workshop on Managing Perfluorinated Chemicals and Transitioning to Safer Alternatives Geneva, Switzerland 12-13 February, 2009 Organized by UNEP and the U.S. Government (U.S. EPA). Retrieved February 20, 2015, from http://www.unep.org/chemicalsandwaste/UNEPsWork/WorkshoponManagingPerfluorinatedChemicals/tabid/104443/Default.aspx

Wang Z., I.T. Cousins, M. Scheringer, R.C. Buck, K. Hungerbühler, Environment International 70 (2014) 62-75.

Wang, T., Wang, Y., Liao, C., Cai, Y., & Jiang, G. (2009). Perspectives on the Inclusion of Perfluorooctane Sulfonate into the Stockholm Convention on Persistent Organic Pollutants. *Environmental Science & Technology*, 43(14), 5171-5175. doi: 10.1021/es900464a

WSC (World Semiconductor Council) (2006). Joint Statement from World Semiconductor Council Meeting of May 2006. http://www.semiconductorcouncil.org/wsc/wsc-meetings

WSC (World Semiconductor Council) (2007). Joint Statement from World Semiconductor Council Meeting of May 2007. http://www.semiconductorcouncil.org/wsc/wsc-meetings

WSC (World Semiconductor Council) (2011). Joint Statement from World Semiconductor Council Meeting of May 2011. http://www.semiconductorcouncil.org/wsc/wsc-meetings

Xie S., T. Wang, S. Liu, K.C. Jones, A.J. Sweetman, Y. Lu, Environment International 52 (2013) 1 -8

Zero Discharge of Hazardous Chemicals (ZDHC). (2014) Manufacturer Restricted Substances List http://www.roadmaptozero.com/programme-documents.php

Zero Discharge of Hazardous Chemicals (ZDHC). (2015a). Retrieved March 25, 2015, from http://www.roadmaptozero.com/members.php

Zero Discharge of Hazardous Chemicals (ZDHC). (2015b). Statement on the phase out of long chaifluorinated chemicals. Retrieved March 25, 2015, from http://www.roadmaptozero.com/df.php?file=pdf/Phaseout.pdf

Zushi, Y., Hogarh, J., & Masunaga, S. (2012). Progress and perspective of perfluorinated compound risk assessment and management in various countries and institutes. *Clean Technologies and Environmental Policy,* 14(1), 9-20. doi: 10.1007/s10098-011-0375-z

This document has been prepared by the OECD/UNEP Global PFC Group with the aim of raising awareness of perfluorinated chemicals in governments, the private sector and civil society. The analysis provides an overview of current activities with regard to the development of risk reduction approaches for per- and polyfluoroalkyl substances in a number of jurisdictions. This work supports efforts in the framework of the Strategic Approach to International Chemicals Management (SAICM) to improve information sharing at a global level on these chemistries.

www.oecd.org/ehs/pfc