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Updated National Implementation Plan for the Stockholm Convention 2018

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Summary

Stockholm Convention

The Stockholm Convention on Persistent Organic Pollutants (referred to as POPs) was adopted in May 2001 and entered into force on 17 May 2004. The purpose of the Convention is to protect human health and the environment against the harmful properties of POPs. The Convention initially included 12 substances or groups of substances (sometimes referred to as "the dirty dozen") and has subsequently been amended, adding 16 additional substances or groups of substances. Of the 16 substances or groups of substances, 6 have been added since the previous implementation plan.

Denmark ratified the Convention on 17 December 2003, with a territorial exclusion in respect of Greenland and the Faroe Islands. The exclusion in respect of the Faroe Islands was withdrawn effective as of the second half of 2012, but the exclusion in respect of Greenland is still valid. In recent years, Denmark has supported an assessment of the consequences of Greenland's possible withdrawal from the exclusion. This report only covers the situation in Denmark; therefore, it does not include activities in the Faroe Islands.

The implementation plans

Denmark's first plan for implementation of the Convention was submitted in 2006. According to the Convention, all parties are required to periodically update the implementation plan and an updated plan was submitted in 2012. This is the third implementation plan. The report is written as a stand-alone document and it is not necessary to read the previous plans at the same time. Therefore, the introduction includes some information repeated from previous plans. The previous plans contained, however, more detailed information for some of the substances than this current plan and may be used as supplemental reading.

Audiences

The report has more audiences:

- The Stockholm Convention Secretariat and the Conference of the Parties, the purpose of which is to describe what steps Denmark is taking to implement the requirements of the Convention. Information about the POP situation in each country also helps to understand the status of problems with POPs across the globe.
- The EU Commission and the other EU Member States, with a view to exchanging information about challenges related to POP substances and the EU Member States' solutions to these.
- Politicians and public institutions, to get an overview of who does what and develop a common understanding of why different actions are taken.
- Environmental organizations, business organizations, researchers and other organizations and individuals with an interest in the POP problem, fulfilling the essential element of the Stockholm Convention that the population must be involved in the development of the implementation plans and that there is wide public discussion about the need for new activities.

Advisory group. The plan has been prepared by the Ministry of Environment and Food (MFVM). The work has been followed by an advisory group with representatives of the MFVM, Danish Environmental Protection Agency, Danish Veterinary and Food Administration, Danish Health and Medicines Authority, Danish Transport, Construction and Housing Authority, Central Organisation of Industrial Employees in Denmark (CO-industri), United Federation of Danish Workers (3F), Danish Society for Nature Conservation, Confederation of Danish Industry, Danish Chamber of Commerce, Ecological Council, Danish Consumer Council TÆNK, Aarhus

University, Center for Energy and Environment (DCE), National Association for Information on Wood Stove Pollution (LOB), and Dakofa, Waste and Resource Network Denmark.

Structure. The structure of the implementation plan is described in section 1.1.3.

The POPs

Substances under the Stockholm Convention are divided into three groups, each of which is listed in its own Annex to the Convention:

Annex A:	Substances Parties must ban (with some time-limited exemptions for specific uses)
Annex B:	Substances Parties must restrict
Annex C:	Substances formed unintentionally, the formation of which Parties must restrict or, if possible, eliminate

The Convention prescribes that stocks containing or consisting of POPs must be identified and handled safely. Wastes that contain or are contaminated with POPs must be disposed of in such a way that the POP content is destroyed or converted irreversibly so that it does not display POP properties. If this does not represent the environmentally preferred possibility or if the POP content is low, the waste may be disposed of in another environmentally responsible manner. The Convention does not contain any limit values in relation to waste but waste management guidelines, which have been prepared for the implementation of both the Basel Convention and the Stockholm Convention, suggest some limit values which for most of the substances comply with the limit values used in the EU. Similarly, the Stockholm Convention does not contain limit values for the release of unintentional POPs, but guidelines have been prepared for the use of BAT (best available techniques) and BEP (best environmental practice). This allows the parties to implement the Convention at different levels depending on their economic and technical capabilities.

The POPs have the characteristics of being persistent (non-degradable), accumulating in the food chain, hazardous and having the ability to be transported over long distances, so activities in each country affect the regional or global environment. Many of the substances do not have particularly high acute toxicities to humans, but as the substances do not degrade and do accumulate in the body, they can result in a number of health effects over time, the extent to which it can be difficult to assess.

Legislation in the POPs area

The regulation of POPs and POPs-containing waste in Denmark is characterized by close interaction between EU and national legislation. Most rules on the POP area in Denmark have originated through the implementation of the provisions of the Convention in EU legislation. The Stockholm Convention is implemented in Regulation (EC) No 850/2004 on Persistent Organic Pollutants (the POP Regulation) with subsequent amendments made as a consequence of the addition of new substances and the establishment of new limit values on the content of the substances for articles and waste. The POP Regulation generally regulates the use of the intentionally used substances and regulates the limit values for the substances in waste. Since it is a regulation, the rules are immediately applicable in all EU countries and should not be transposed into national law. A few of the substances that have been added since the last plan are not yet restricted under the POP Regulation but rather under the EU Chemical Regulation REACH, because the POP Regulation could not be modified for technical reasons. The regulation is currently undergoing recasting in order to address this. For some of the substances, there are some exceptions to the restrictions; it is an ongoing process to assess whether these exceptions are still necessary. This work typically takes place at EU level and the EU Commission also draws up an EU-wide implementation plan.

The POP Regulation is supplemented by a number of other regulations, the Danish Environmental Protection Act and Chemicals Act, as well as a number of Statutory Orders issued pursuant thereto. A large portion of the legislation has been updated since the preparation of the previous implementation plan.

A considerable number of the current issues relates to the presence of the substances in waste and its proper handling, to contamination of soil and groundwater and to the unintentional formation and release of POPs. For these areas, apart from establishing limit values for waste in the POP Regulation, other legislation sets the framework for the handling of POPs. In these areas there may be interpretative problems, for example in relation to the combustion of materials containing POPs.

The six substances added since the last implementation plan

For the six substances/substance groups that have been added since the last implementation plan, the report contains a systematic review of the situation in Denmark. In the following, a brief summary of the uses and consumption of the substances, the most important current issues and information on the extent to which exposures for the substances in Denmark are considered to take place and give cause for concern are provided for each substance/substance group. For descriptions of other areas, reference is made to the more comprehensive description in the substance-specific sections of the report.

Hexachlorobutadiene (HCBD). HCBD, like other POPs pesticides, has not been used in Denmark for many years, and it is believed that there are currently no stocks of old POP pesticides in Denmark. There are no significant current issues related to HCBD. There are very few data for HCBD in food and drinking water, but exposure to HCBD is considered to be insignificant on the basis of available information. It is assessed that no further initiatives in relation to HCBD are needed.

Decabromodiphenyl ether (decaBDE). DecaBDE has been used as a flame retardant until recently, primarily in flame retarded plastics in electronics and building materials and in textiles used in vehicles, among others. DecaBDE is part of the group of polybrominated diphenyl ethers (PBDEs) and has historically represented the most significant substance as regards consumption of the PBDEs.

According to a substance flow analysis from 1999, the consumption of brominated flame retardants in Denmark at the time was 332-660 tonnes, of which 10-120 tonnes were PBDEs. The consumption of decaBDE was not separately estimated but made up the majority. The bulk of PBDE was imported with articles. At that time, decaBDE and other PBDEs were largely phased out in the production of plastic for electronics in Denmark for occupational health reasons because decaBDE was always used along with the carcinogen antimony trioxide (used as a synergistic flame retardant). DecaBDE has been banned in electrical and electronic products since 2008 with certain exemptions which have subsequently been repealed. There are no more recent estimates of consumption in Denmark than the 1999 inventory.

Current issues are primarily considered to relate to the occurrence of decaBDE in waste and recycled plastics. DecaBDE would be included in plastic waste from dismantling of waste electrical and electronic products (WEEE). In Denmark, plastic with brominated flame retardants from WEEE must be disposed of to companies approved for handling of bromine-containing waste. Virtually no final treatment of WEEE occurs in Denmark, but some pre-sorting of the waste takes place. If flame-retarded plastic is recycled, decaBDE can be incorporated into new products if sorting of the plastic is insufficient. Investigations have shown that decaBDE can be present in plastics in imported products as a result of recycling of plastic outside Danish borders. DecaBDE in textiles in cars ends up in shredder waste. The issues related to shredder waste are mentioned below under PCB, considered to be the most problematic POP in shredder waste; its presence determines how the waste is handled. The destruction efficiency for decaBDE as well as other POPs in waste incineration plants is discussed below.

The most important exposure to decaBDE is via food and dust in the indoor environment. The European Food Safety Authority (EFSA) estimates that intake of decaBDE with food does not raise concerns in the EU. Studies indicate that exposure to dust could be the major route of exposure, but since decaBDE containing electrical and electronic products are at least 14 years old currently, and thereby close to the end of their service life, this route of exposure is likely to be steeply decreasing.

Four other PBDEs, that are listed under the Convention, are described in detail in the most recent implementation plan. These were included in the two commercial PBDE mixtures octaBDE (octabromodiphenyl ether) and pentaBDE (pentabromodiphenyl ether). The substances have been banned for many years in the EU and products containing the substances are likely largely disposed of.

New initiatives. New initiatives regarding decaBDE and other PBDEs include control of products on the Danish market. MFVM will also assess how materials with PBDEs can be separated from the waste stream before recycling and other waste treatments and prepare guidance for recyclers.

Short-chain chlorinated paraffins (SCCPs). Chloro paraffins are divided into three groups: short-, medium- and long-chain. Only the short-chain chloro paraffins (SCCPs) are covered by the Stockholm Convention. SCCPs are currently banned, but there is an exemption for mixtures with concentrations up to 1% and for articles with concentrations up to 0.15%, meaning that, for example, mixtures of medium-chain chlorinated paraffins (MCCPs) can be up to 1% SCCP as a result of contamination. The 1% is also the concentration used as the limit value determining when materials should be disposed of as hazardous waste.

There are no surveys of the current applications in Denmark or the total consumption of SCCPs with mixtures where the substances may be present in concentrations of up to 1%. Total consumption of SCCPs in mixtures with <1% SCCPs registered in the Product Register in 2016 was 0.1 kg. Although the Product Register covers only professional use, the results suggest that current consumption of SCCP with mixtures is limited. SCCPs could occur as impurities in mixtures of medium-chain chlorinated paraffins (MCCPs), *inter alia* used in cooling/lubricating agents and fillers.

No information has been found on articles that may contain SCCPs in concentrations of up to 0.15%. It is stated in the background for the restriction in the EU that the concentration is based on the amount of SCCPs allowed as impurities in an article produced with medium-chain chlorinated paraffins (MCCPs). MCCPs is imported particularly in articles of PVC or rubber where the substance is used as a plasticizer.

Current issues are primarily considered to relate to the occurrence of SCCPs in construction materials and waste. SCCPs may primarily occur in waste streams in the form of paint and sealants used in buildings and in rubber used in vehicles. Studies on the occurrence of SCCPs in building materials in connection with renovation and demolition showed that SCCPs were primarily found in sealants (29% of the investigated sealants taken from buildings from the relevant period). Of 170 samples with SCCPs, 115 had concentrations of more than 1% and should therefore be disposed of as hazardous waste. SCCPs was also found in a concentration of more than 1% in one sample of paint and one sample of floor tile. The Danish Working Environment Authority has not prepared instructions for work with SCCPs, but has stated that the same instructions for working with PCBs (polychlorinated biphenyls) will apply to SCCPs. Since the absolute concentrations of SCCPs in the materials correspond to the concentrations of PCB, but the limit for treatment as hazardous waste is 20 times higher for SCCPs than for PCBs, the risk of contamination of adjacent materials to levels above the limit value is much lower than for PCB. Consequently, the amounts of building waste contaminated with SCCPs should be expected to be far lower than the amounts contaminated with PCBs. There does not seem to be an indoor climate problem with SCCPs.

No monitoring of SCCPs in food takes place in Denmark, but according to the EU risk assessment for SCCPs, consumer exposure is not cause for concern.

New initiatives. MFVM will evaluate the need for further information regarding the identification and management of SCCP waste for contractors, property owners, municipalities and other stakeholders involved in renovation and demolition activities. If the evaluation shows that additional information is required, MFVM will prepare the necessary guidance.

Pentachlorphenol (PCP) was previously used for wood preservation with consumption in the mid 1970s of 1.0-1.5 t/year. It was primarily used for surface treatment and was not reportedly used for railway sleepers or telephone piles. PCP has not been used in Denmark since 1979 but was only formally banned in 1996. Besides, PCP has occurred in low concentrations in certain types of imported wood, e.g. in transport pallets.

The issues have primarily related to the presence of dioxins as contaminants in PCP and PCP-containing materials, which had previously been a significant source of dioxin emissions. Releases of dioxins from preserved wood in use and in imported pallets was investigated in Denmark in 2004. Since PCP has not been used for preservation for 40 years, it is expected that there would hardly be any wood impregnated with PCP in use today, and that the resulting emissions of dioxins would be insignificant.

The intake of PCP with food is significantly below the tolerable daily intake, and exposure of consumers to PCP does not give rise to concern.

It is assessed that no further initiatives in relation to PCP are needed.

Hexabromocyclododecane (HBCDD). HBCDD was used as flame retardant for polystyrene foams (EPS and XPS) used as insulation material in building and construction, plastics in electronics and, to a lesser degree, in flame retardant fabrics in, *inter alia,* vehicles until recently. Total consumption in Denmark in 1999 was estimated at 26-80 t/year, of which 13-36 t/year were used in building materials. A recent survey from 2014 indicated that consumption of building materials was probably at the same level as in 1999, but no accurate quantitative inventory was made. However, the consumption of HBCDD for the production of EPS/XPS in Denmark had decreased from a level of 6-13 t/year in 1999 to about 1 t/year in 2012.

In the EU, the main application of HBCDD has been EPS ("flamingo") used as insulation material, but in Denmark, flame retardant grades have not typically been used. The material has mostly been used below ground or on concrete deck where there was no need for flame retardancy. XPS has typically been flame retarded, although it was used below ground where flame retardancy was not required.

The main issues relate to HBCDD in waste. Discarded EPS and XPS from the construction are typically disposed of for waste incineration in municipal solid waste (MSW) incinerators and no waste sorting of HBCDD is carried out. Studies indicate that the substance is completely destroyed in MSW inclinators, but a Swedish review of existing knowledge of destruction efficiencies notes that the number of studies is still limited. There is an ongoing Danish survey aimed at clarifying the destruction efficiency of Danish plants.

Food intake of HBCDD is assessed by the European Food Safety Authority (EFSA) to be below the tolerable daily intake and exposure of consumers to HBCDD is not considered a cause for concern. With the use of flame retarded EPS and XPS that has taken place in Denmark, it is assessed that there is no risk that HBCDD from the insulation materials will cause elevated levels of HBCDD in indoor air.

New initiatives. Based on an evaluation of the efficiency of the combustion of HBCDD in MSW incinerators, MFVM will assess whether sorting, with the aim of destruction of the EPS and XPS with HBCDD, is required.

MFVM will also evaluate the need for additional information for the identification and handling of HBCDD waste to contractors, property owners, municipalities and other stakeholders involved in renovation and demolition activities. If the evaluation shows a need for further information, the MFVM will prepare the necessary guidance.

Polychlorinated naphthalenes (PCN). There are no issues related to the previous, intended use of PCN. Unintentional formation of PCN is mentioned under release of dioxins and other unintentionally formed POPs.

Substances covered by the previous implementation plans

For substances covered by the previous implementation plans, reference is made to these plans for a more systematic review of the situation in Denmark. The following briefly describes which initiatives have been implemented since the last plan and issues still considered to be significant for the substances in question.

PCB

Polychlorinated biphenyls (PCBs) have been listed under the Convention since it came into force and PCBs, together with dioxins, are the POPs which have resulted in the most extensive activities in Denmark. PCB was regulated in Denmark and in the EU long before the Stockholm Convention came into force. Use of PCB in open applications such as paint and sealant was banned in Denmark in 1977 and later, in 1986, a ban on the use of PCB in electrical equipment followed. However, PCB materials have been shown to have long lifespans and over the last 10 years there has been increased awareness of PCB in materials still in use and possible health consequences.

PCB in buildings. The previous plan referred to the Action Plan for Handling PCBs in Buildings from 2011, which had 19 initiatives that were implemented in the subsequent period. A survey of PCBs in buildings from the PCB period (1950-1977) showed that a large portion of the building stock contained PCB materials in concentrations above the detection level. Furthermore, it was shown that there were a large number of buildings, including schools and day-care centres, that had PCB in indoor air that exceeded the recommended action levels set by the Danish Health Authority. As a consequence of the widespread occurrence of PCB in materials, the Statutory Order on Waste introduced requirements for inventories of PCBs in buildings from the PCB period in connection with renovation and demolition. The inventories have resulted in a pronounced increase in the amounts of PCB-containing construction waste, as discussed below. The survey also showed a widespread occurrence of PCBs in small capacitors in fluorescent light fixtures and that the capacitors, if leaking, could result in PCB concentrations in the indoor environment exceeding the recommended action levels. Consequently, the Danish Environmental Protection Agency prepared a guide on the identification and handling of these capacitors and launched a campaign with a call to replace the old fixtures.

As a result of the increased focus on PCB in buildings, the recorded quantities of PCB-containing building materials have increased from about 50 t/year in 2007/2008 to 800 tonnes in 2011 and further to 8,000 tonnes in 2014 cf. the Danish Environmental Protection Agency's waste database system. Part of the increase has occurred because previously, waste was primarily registered if it contained more than 50 mg/kg PCB, which is the limit for the waste to be defined as hazardous, whereas the majority of waste registered in recent years contains PCBs in lower concentrations.

Destruction of PCB in waste incineration plants. The large amounts of PCB waste in lower concentrations have been the basis of a number of studies as to whether it could be incinerated in waste incineration plants for household waste in order to reduce the costs of disposal. This has resulted in some debate about the disposal of PCB-containing waste for these plants. The same considerations and debate have also taken place about incineration of shredder waste containing PCBs, such as stems from small capacitors. Each year, 100,000-150,000 tonnes of shredder waste are generated and 1.8 million tons of shredder waste is currently landfilled. On average, the PCB content in new waste is slightly lower than the limit of 50 mg/kg, while the deposited waste is about the limit value. The total amount of PCB in landfilled waste is roughly calculated at approx. 90 tonnes. This waste also contains other POPs - especially PBDEs and PFOS. There is a political interest in incinerating shredder waste in order to utilize the energy content and move shredder waste management one step up in the waste hierarchy (from landfilling to incineration with energy recovery). The high values for PCB in new shredder waste could indicate that capacitors in equipment were not adequately removed from the equipment before shredding. A literature review on the destructive efficiency of household waste incineration plants found that destructive efficiency was in the 90-99% range, while the majority of the remaining contents were captured during flue gas cleaning, while 1% was emitted with the flue gas. However, the study mentions that it is difficult to extrapolate from the available studies to Danish plants in use today. For comparison, guidelines for the Basel and Stockholm Convention recommend a destruction efficiency of >99.999% for waste with a PCB concentration of > 50 mg/kg.

PCB in electrical equipment. Large PCB-containing devices with >500 mg/kg PCB should have been disposed of or decontaminated in Denmark by January 1, 2000. Large amounts of capacitor and transformer waste with less than 50 mg/kg of PCB are still in society. For the period 2011-2016, the volumes ranged from about 50 t/year to 580 t/year. The Danish Environmental Protection Agency has initiated an investigation into the occurrence and handling of PCB in larger transformers and capacitors in Denmark. The preliminary results indicate that large transformers with more than 500 mg/kg PCB have been disposed of and that about 98% of the waste from Danish waste producers are transformers with contents of less than 50 mg/kg PCB, which are handled by companies with the required permit. Approximately 2% is disposed of as hazardous waste. The investigation is not finished and detailed information on the handling of PCB-containing equipment and transformer oils has not yet been evaluated.

PCB in food. The level of PCB in food remains a cause for concern. PCB in food occur primarily in fish, dairy products, fat and meat. The intake of PCB with food has decreased to about ¼ of the level that in the 1970s. Monitoring distinguishes between the dioxin-like PCBs, described below with the dioxins, and the non-dioxin-like PCBs. For non-dioxin-like PCBs, up to 1-5% of the population have an intake above the tolerable weekly intake. In Denmark, the largest contribution comes from fish and fish products (about 32%) followed by dairy products, fat and fat products, and meat and meat products.

PCB in the indoor environment. The previous implementation plan referred to measurements of PCB in blood from residents of apartments with high contents of PCB in materials and the Danish Health Authority's recommendation that more studies be carried out that included both indoor climate and blood analyses in order to obtain a better understanding of the results in a national context. The studies performed showed that the level of non-dioxin-like PCB in the blood was approximately three times higher in subjects exposed to the indoor environment relative to a control group, whereas for the dioxin-like PCBs, levels were approximately twice as high. It was assessed that there would not be immediate acute health effects. However, subjects exposed to PCB in the indoor environment are particularly exposed to PCB with low degrees of chlorination, whose potential effects are less known. Therefore, an extensive research project, HESPERUS, has been initiated with the participation of a number of research institutions in Denmark and abroad in order to investigate the health effects of living in houses or staying in institutions with PCB in the indoor environment. The project examines the possible effects of low-chlorinated PCB congeners [1] and links indoor air measured exposures to PCBs in Denmark with a number of health outcomes from nationwide registers to form the basis for an ongoing research programme.

New initiatives. MFVM will complete the ongoing study of PCB in transformers and capacitors and evaluate the extent to which further initiatives are needed.

The results of the ongoing HESPERUS project that assess the risk of low-chlorinated PCB in the indoor environment will be followed and the extent to which further actions will be required as a result of the project will be examined.

MFVM will review the destruction efficiency of PCBs in MCW incinerators along with the results of an ongoing assessment of the destruction efficiency for other POPs. On this basis, the Ministry will assess the need for further initiatives.

PFOS

PFOS is used in this context as the collective term for perfluorooctane sulfonic acid, its salts, and perfluorooctanesulfonic fluoride, PFOSF. In general, as regards the uses of PFOS in society, human exposure or PFOS in the environment, studies in Denmark include several substances within the group of per- and polyfluoroalkyl substances (PFAS). Like PFOS, other PFAS substances are persistent and two other PFAS (PFHxS (perfluorohexane sulfonic acid) and PFOA (perfluorooctanoic acid)) are under review for listing under the Convention. In assessing potential effects of the substances, consideration should be given to the total load of the substances and the exposure to PFOS forms only part of the overall picture.

Intentional applications. The POP Regulation provides an exception for the use of PFOS for non-decorative hard chromium plating, and PFOS was used for this purpose up until a few years ago in Denmark. Denmark has notified the Convention's Secretariat of the use of PFOS for this application. At present, this use has ceased as PFOS has been replaced by a shorter-chain PFAS. For other applications, PFOS has not been intentionally used for many years and is expected to largely be removed from the waste stream. PFOS can act as an impurity in mixtures of PFAS, but studies conducted in Denmark on PFAS in children's clothes, carpeting carpets and food packaging of cardboard and paper have not found PFOS in concentrations above the permitted concentration in the POP Regulation.

Articles containing PFOS are, when becoming waste, typically disposed of for MSW incineration. Available results indicate that the substances are sufficiently destroyed in MSW incinerators, but experts state that there is still great uncertainty about this. As mentioned, a Danish assessment is currently undertaken.

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[1] PCBs, dioxins, furans and PBDEs consist of a number of substances known as congeners, characterized by the number of chlorine atoms and the location of the chlorine atoms in the molecule. Different congeners have different toxicities and different physical and chemical properties that affect their dispersal in the indoor environment and the environment.

Food intake. The National Food Institute assesses the input of PFOS with food to be below the tolerable daily intake, based on intake of fish, which is generally considered to be the most significant source. There is a particular focus on the use of PFAS in cardboard and paper used for food packaging and exposure thereto. The Danish Veterinary and Food Administration's analyses of food packaging of cardboard and paper have not identified PFOS or nine other perfluoroalkyl sulfonic acids (PFSA) and substances that can be degraded to PFSA in concentrations above the detection limit. However, few PFAS are included in the analysis. The Danish Veterinary and Food Administration discourages the use of PFAS in cardboard and paperboard packaging for foodstuffs and has set an indicator value of 10 µg total organic fluorine per dm^2 paper.

Soil and groundwater pollution. The most important current issue in relation to PFOS is soil and groundwater contamination on areas used for fire-fighting training grounds where PFOS-containing fire extinguishing foam was previously used. PFOS has typically been used in mixtures with other PFAS and studies have included a number of PFAS. This type of fire extinguishing foam has been used mostly for extinguishing oil fires and has therefore been used in particular for firefighting near airports. Relatively high concentrations of soil and groundwater have been found at the investigated fire-fighting training grounds, and in one place the concentrations were so high that remediation was established. Screenings of groundwater magazines have furthermore demonstrated that samples taken near fire-fighting training grounds have measurable concentrations of PFOS. In addition, PFOS has been found in soil and groundwater in connection with a carpet factory where PFOS-containing impregnating agents had been used. In a screening survey from 2014, PFAS was found on half of the sites investigated in concentrations at or above the level of the Danish criteria for PFAS in drinking water and groundwater. There has been no assessment of the health significance of these exceedances. A desk study identified other sites potentially contaminated with PFOS and PFAS from former uses of PFOS-containing mixtures. These include the chromium plating industry, textile industry and paint industry.

New initiatives. As PFOS is no longer used as a mist suppressant in non-decorative hard chromium plating, Denmark will withdraw the notification of this application. In addition, Denmark will inform the Stockholm Convention Secretariat and the EU Commission its experience with the substitution of PFOS for this application.

In 2014, the Nature Agency gave instructions to the municipalities regarding the control of PFAS in drinking water in places where PFOS and other PFAS were used. By 2018, the Region's Knowledge Center for Environment and Resources published a handbook on the investigation and prevention of pollution with PFAS connections. It is therefore considered that there is no need for further initiatives from MFVM in relation to soil and groundwater contamination with PFAS at present.

MFVM will assess the need for further initiatives when a study on the destruction of PFOS and other POPs in MSW incinerators has been completed.

Dioxins[2] and other unintentionally formed POPs

Emissions of dioxins. Dioxins have never been produced intentionally but are unintentionally formed by a number of industrial chemical processes and combustion processes. Emissions of dioxins (PCDD/PCDF) from combustion plants and industry in Denmark have decreased to a level below 5% of the level in 1990s, largely as a consequence of the introduction of a EU-

[2] "Dioxins" are used herein as a common name for the group of polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF). The concentration of these is normally reported jointly and converted to a measure of the dioxin toxicity of the substances (in the TEQ unit).

level emission limit value for dioxins. The main sources of dioxin emissions today are the same as during preparation of the previous plan: the burning of biomass in wood-burning stoves and other small combustion plants, as well as fires. Stoves and other small combustion plants account for about 60% of total emissions. Better firing techniques that can reduce emission of particulate matter and PAH (polyaromatic hydrocarbons) from wood stoves have unfortunately had no effect on dioxin emissions. The national inventories of dioxin emissions account for three types of wood-burning stoves, and it is presumed that the newest eco-labelled wood-burning stoves have significantly fewer emissions than the old ones. However, the Statutory Order on wood stoves does not lay down rules for the release of dioxins in connection with the type approval of stoves. Old high-emission stoves still account for more than half of all stoves, and the vast majority of estimated emissions. According to these inventories, emissions will decrease by replacing old ovens with new ones over time. However, recent Danish studies cannot confirm that the emissions are generally significantly lower in new stoves, but emphasise that the composition of the fuel is likely to have a greater influence on the formation of dioxins.

Seasonal variations in the dioxin concentration in the air above the Baltic Sea indicates that non-industrial combustion processes probably are the most important sources. Model calculations from 2012 show that 49% of the atmospheric deposition of dioxins to the Belt Sea originates from Danish sources, while Danish sources account for 41% of the atmospheric deposition to the Kattegat. For other sub-basins in the Baltic Sea region, the contribution from Danish sources is low.

Dioxins in flue gas cleaning products. The previous implementation plans have reviewed information on the formation of dioxins in waste incinerators. With the improvement of flue gas cleaning as regards dioxins, emissions to air have been reduced, so that incineration plants currently represent a small fraction of the total emissions of dioxins. At the same time, however, a larger proportion of the dioxins formed end up in the residues from flue gas purification. The previous implementation plan therefore included a proposed action to investigate the possibilities for improved treatment of flue gas purification residues. However, the residues from MSW incinerators are still exported for landfill in a former limestone quarry in Norway or in abandoned salt mines in Germany. There is currently a project under implementation (HALOSEP) which investigates the options for treating the flue gas cleaning products in a way that avoids export and landfill of flue gas cleaning residues.

Dioxins in foods. The presence of dioxins in food is still causing concern. When monitoring in food, dioxins are measured together with dioxin-like PCBs and are reported with a total measure of dioxin toxicity. The content of dioxins and dioxin-like PCBs in certain animal foods is still high. Requirements for risk management measures have been introduced for the marketing of certain fish species from the Baltic Sea and adjacent waters due to excessive contents of these substances. In addition, high levels have been found in eggs from free-range hens from some farms and in horsemeat, so the Danish Food Agency recommends, *inter alia*, that consumers limit their intake of salmon from the Baltic Sea, cod liver, horsemeat and liver from sheep and wild game and that consumers buy eggs from different stocks. The exposure to dioxins and dioxin-like PCBs occurs primarily through food. Fish accounts for the largest contribution to exposure (31%) followed by dairy products and meat, while eggs contribute less than 5%. In November 2018, the European Food Safety Authority (EFSA) lowered the tolerable weekly intake (TWI) for dioxins or dioxin-like PCBs, meaning that the average exposure of these substances in Denmark is almost twice the new recommended TWI. There is, however, still some uncertainty regarding the toxicity of one of the important PCB congeners which has influence on the assessment. As consequence of the lower TWI, the Danish Food Agency has December 2018 changed the agency’s recommendations to consumers.

Swedish studies of sources of dioxins in herring in the Baltic Sea reveal that combustion processes are probably the most important sources, but the studies do not assess the extent to which the release of dioxins accumulated in sediments from historical emissions contributes to the current occurrence of dioxins in the fish.

Other unintentionally formed POPs. The other unintentionally formed POPs listed under the Stockholm Convention are PCB, hexachlorobenzene (HCB), pentachlorobenzene, HCBD and polychlorinated naphthalenes (PCN). Of these, release inventories are available for HCB and the dioxin-like PCB. For HCB, the main sources are waste incineration plants and diesel fuelled vehicles. The level has been constant for many years, but releases were approximately 10 times greater in the early 1990s when HCB still occurred in pesticides. HCB is monitored in food with other chlorinated pesticides. Ingestion with food is generally below the toxicological reference values for these pesticides. Sources of unintentionally formed dioxin-like PCBs are primarily diesel fuelled vehicles. There has been a slight increasing trend in emissions over the last 20 years. Before this time, the emissions were about five times greater because gasoline cars that used leaded petrol resulted in much greater emissions. There are no inventories of releases to the environment of residual PCBs in building materials and electrical equipment.

New initiatives. Studies conducted indicate that the formation and emission of dioxins from wood stoves is significantly lower when burning clean wood. The MVFV will inform the users to use clean and dry wood and not to burn waste in wood stoves in its future campaigns.

As there are no reports of releases of accidentally formed HCBD and PCN, screening studies of emissions of these substances will be carried out.

The progress of the ongoing HALOSEP project will be followed and, on the basis of the results, MFVM will assess whether further activities should be initiated and whether changes to the legislation regarding the disposal of flue gas cleaning products should be made.

Particularly exposed population groups

There may be exposure to POPs in the working environment associated with a number of processes. In construction, workers may be exposed to PCB and SCCP in connection with renovation and demolition, and instructions for handling materials containing the substances have been prepared. Renewal and demolition could also result in exposure to HBCDD in insulation materials, but the EU Risk Assessment for HBCDD estimates that exposures by these activities are insignificant in relation to other exposures. Foreign studies have demonstrated significant exposure to PBDEs in the treatment of electronics waste, but limited treatment of electronics waste currently takes place in Denmark. There may be some exposure to dioxins and other POPs in connection with sources for the formation of these substances. Foreign surveys of chimney sweep and employees at incinerators have not found exposure levels significantly above the general population. A UK study of occupational exposure to dioxins in a number of sectors found that secondary production of aluminium and steel in particular resulted in significant exposures, but such production does not take place in Denmark.

Women of childbearing age and pregnant or breastfeeding women are particular risk groups because POPs can be transferred to foetuses and new-borns, which are particularly sensitive to the effects of POPs. It is therefore recommended that these groups limit their intakes of certain types of fish and other high-content POPs.

Other activities

The country baseline provides information about POP monitoring programs, information for the population, activities of NGOs, etc. For these sections, reference is made to the report text.

Summary

New initiatives and activities for Denmark's further implementation of the Stockholm Convention are summarized in the table below.

TABLE 1. New initiatives and activities for Denmark's further implementation of the Stockholm Convention

Substance/ Area	No	Initiatives
DecaBDE and other PBDEs	1	Undertake control of products on the Danish market. Assess how materials with PBDEs can be separated from the waste stream prior to recovery and other waste treatment. Prepare advice for recycling companies.
SCCPs	1	Evaluate the need for further information on SCCP-waste to contractors, property owners, municipalities, and other stakeholders involved in activities related to building renovation and demolition. If the evaluation demonstrates the need for further information, the MFVM will prepare such information.
HBCDD	1	Assess whether selective sorting with the aim of destruction of EPS and XPS with HBCDD should be required on the basis of an evaluation of the efficiency of incineration of HBCDD in MSW incinerators.
	2	Evaluate the need for further information on identification and handling of HBCDD-waste to contractors, property owners, municipalities, and other stakeholders involved in activities related to building renovation and demolitions. If the evaluation demonstrates the need for further information, the MFVM will prepare such information.
PCB	1	Finalise ongoing study on PCB in transformers and capacitors and evaluate whether further initiatives are needed.
	2	Follow the results of the ongoing HESPERUS project which assesses the risk of low-chlorinated PCB in the indoor environment. Assess to what extent further actions would be needed based on the results of the project.
	3	Revisit the assessment of destruction efficiency for PCB along with results of the ongoing assessment of destruction efficiencies for other POPs. Assess, on this basis, the need for further initiatives.
PFOS	1	Withdraw notification of PFOS in mist suppressants for non-decorative hard chrome plating. Inform the Secretariat of the Stockholm Convention and the European Commission on Denmark’s experience with the substitution of PFOS for this application.
	2	Evaluate the need for further initiatives based on the results of a desk study on destruction of PFOS and other POPs in MSW incinerators operating at a temperature of 850˚C.
Dioxins and other unintentionally formed POPs	1	Inform users in future campaigns of the need to use clean and dry wood and not to burn waste in wood stoves.
	2	Undertake screening surveys for emissions of HCBD and PCNs.
	3	Follow the progress of the HALOSEP project and, on the basis of the results, assess whether further activities should be initiated and whether changes should be made to the legislation on disposal of flue-gas cleaning products.

Dansk sammenfatning

Stockholmkonventionen

Stockholmkonventionen om persistente organiske miljøgifte (refereret til som POP-stoffer) blev vedtaget i maj 2001 og trådte i kraft 17. maj 2004. Formålet med konventionen er at beskytte menneskers sundhed og miljøet imod POP-stoffernes skadelige egenskaber. Konventionen omfattede i første omgang 12 stoffer eller stofgrupper (som nogle gange omtales som "det beskidte dusin") og er senere blevet udvidet med yderligere 16 stoffer eller stofgrupper. Af de 16 stoffer eller stofgrupper er de 6 kommet til siden den foregående implementeringsplan. Danmark ratificerede konventionen 17. december 2003 med territorialt forbehold for Grønland og Færøerne. Forbeholdet for Færøerne er blevet hævet med virkning fra anden halvdel af 2012, men forbeholdet for Grønland er stadig gældende. Danmark har i de senere år støttet en vurdering af konsekvenserne for Grønland af at ophæve forbeholdet. Nærværende rapport dækker kun situationen i Danmark og omfatter således ikke aktiviteterne på Færøerne.

Implementeringsplanerne

Danmarks første plan for implementering af konventionen blev udarbejdet i 2006. Ifølge konventionen er alle parter forpligtet til periodevist at udarbejde en opdateret implementeringsplan, og en opdateret plan blev fremsendt i 2012. Dette er den tredje implementeringsplan. Rapporten er skrevet således, at den kan stå alene, og det ikke er nødvendigt at læse de foregående planer samtidigt. Derfor er der i introduktionen en del information som går igen fra de tidligere planer. De foregående planer indeholdt for nogle af stofferne mere detaljerede oplysninger end denne plan, og de kan eventuelt bruges som supplerende læsning.

Målgrupper. Rapporten har flere målgrupper:

- Sekretariatet for Stockholmkonventionen og Partskonferencen, hvor formålet er at beskrive, hvad Danmark gør for at implementere kravene i konventionen. Informationer om POP-situationen i de enkelte lande er også med til at danne baggrund for en forståelse af status for problemerne med POP-stofferne på tværs af kloden.
- EU-kommissionen og de øvrige EU-medlemslande med henblik på at udveksle information omkring udfordringer i relation til POP-stofferne og EU medlemsstaternes løsninger på disse.
- Politikere og offentlige institutioner for at få et overblik over, hvem der gør hvad og en fælles forståelse af, hvorfor de forskellige tiltag tages.
- Miljøorganisationer, erhvervsorganisationer, forskere og andre organisationer og enkeltpersoner med interesse i POP-problematikken. Det er et væsentligt element i Stockholmkonventionen at befolkningen inddrages i udviklingen af implementeringsplanerne, og at der er bred offentlig diskussion om behovet for nye aktiviteter.

Følgegruppe. Planen er udarbejdet af Miljø- og Fødevareministeriet (MFVM). Arbejdet har været fulgt af en følgegruppe med repræsentanter for Departementet i MFVM, Miljøstyrelsen, Fødevarestyrelsen, Sundhedsstyrelsen, Trafik-, Bygge- og Boligstyrelsen, CO-industri, 3F, Danmarks Naturfredningsforening, Dansk Industri, Forbrugerrådet TÆNK, Det Økologiske Råd, Center for Energi og Miljø (DCE) ved Aarhus Universitet, Landsforeningen til Oplysning om Brænderøgsforurening og Dakofa. Planarbejdet har været assisteret af COWI.

Planen indledes med en ***introduktion***, som primært er en læsevejledning, der også skitserer, hvorfor og hvordan implementeringsplanen er udarbejdet. Herefter følger i ***kapitel 2*** en ***landebasislinie***. Beskrivelsen indledes med en landeprofil, som kort beskriver relevante danske forhold. Dette afsnit følges af en beskrivelse af de institutionelle, politiske og reguleringsmæs-

sige rammer med fokus på, hvilke ansvarsområder de enkelte institutioner har i relation til POP-stofferne, og hvorledes POP-problematikken hænger sammen med de øvrige miljøpolitiske prioriteringer. I de efterfølgende afsnit beskrives andre relevante internationale forpligtelser og den eksisterende lovgivning vedrørende POP-stofferne. Herefter følger videre i *kapitel 2* en beskrivelse af POP-situationen i landet, som danner baggrund for de senere strategi- og handlingsplanelementer. For de 6 stoffer, der er kommet til siden sidste implementeringsplan, er der en mere indgående beskrivelse af POP-situationen i Danmark, mens der for de stoffer, som er beskrevet i de foregående planer, er fokus på ny viden siden seneste implementeringsplan, herunder fremdriften for igangsatte aktiviteter. Ligeledes beskrives, hvilke aktiviteter der foregår med hensyn til overvågning af POP-stofferne og forskning i deres effekter på mennesker og miljø. Implementeringsplanen sammenfatter på baggrund af tilgængelig viden, i hvilken grad mennesker og miljø i Danmark er udsat for niveauer over fastsatte kriterier.
I ***kapitel 3*** gennemgås punkt for punkt aktiviteter og handlingsplanelementer for opfyldelse af Danmarks forpligtelser under konventionen.

I denne sammenfatning gås der på tværs af opbygningen af rapporten, idet der for hvert stof eller stofgruppe laves en sammenfatning af såvel POP-situationen i landet som aktiviteter og handlingsplanelementer.

POP-stofferne

Stofferne under Stockholmkonventionen er opdelt i tre grupper, som er angivet i hvert sit bilag til konventionen:

Bilag A:	Stoffer, som parterne skal forbyde (der kan være tidsbegrænsede undtagelser for visse anvendelser af stofferne)
Bilag B:	Stoffer, som parterne skal begrænse
Bilag C:	Stoffer, som dannes utilsigtet, og hvis dannelse parterne skal begrænse eller om muligt eliminere

Konventionen foreskriver, at lagre, der rummer eller består af POP-stoffer, skal identificeres og håndteres sikkert. Affald, der består af, indeholder eller er forurenet af POP-stoffer, skal bortskaffes på en sådan måde, at POP-indholdet destrueres eller omdannes irreversibelt, så det ikke udviser POP-egenskaber. Hvis dette ikke udgør den miljømæssigt foretrukne mulighed, eller hvis POP-indholdet er lavt, skal affaldet bortskaffes på anden miljømæssig forsvarlig måde. Konventionen indeholder ikke grænseværdier i relation til affald, men i de vejledninger om håndtering af affald, som er udarbejdet til brug for implementeringen af både Baselkonventionen og Stockholmkonventionen, er der angivet grænseværdier for de fleste stoffer, som er i overensstemmelse med grænseværdier, som anvendes i EU og nævnes nedenfor. Ligeledes indeholder Stockholmkonventionen heller ikke grænseværdier for udslip af utilsigtet dannede POP-stoffer, men der er udarbejdet vejledninger, der foreskriver anvendelse af BAT (bedste tilgængelige teknikker) og BEP (bedste miljømæssige praksis). Hermed er der mulighed for, at parterne kan implementere konventionen på forskellige niveauer afhængig af deres økonomiske og tekniske formåen.

POP-stofferne er karakteristiske ved, at de er persistente (svært nedbrydelige), ophobes i fødekæden, er giftige og kan transporteres over lange afstande, så aktiviteter i det enkelte land påvirker det regionale eller globale miljø. Mange af stofferne har ikke en særlig høj akut giftighed over for mennesker, men da stofferne ikke nedbrydes og ophobes i kroppen, kan de over tid give en række helbredseffekter, hvis omfang det kan være vanskeligt at vurdere.

Lovgivning på POP-området

Reguleringen af POP-stofferne og POP-affald i Danmark er karakteriseret ved et tæt samspil mellem EU-lovgivningen og national regulering. De fleste regler på POP-området i Danmark er en følge af implementering af konventionens bestemmelser i EU-lovgivning. Stockholmkonventionen er i EU gennemført i Forordning (EF) nr. 850/2004 om persistente organiske miljøgifte (POP-forordningen) med efterfølgende ændringer og tilføjelser som konsekvens af tilføjelse af nye stoffer og fastlæggelse af nye grænseværdier for stoffernes forekomst i artikler og affald. POP-forordningen regulerer generelt brugen af de tilsigtet anvendte stoffer og regulerer grænseværdier for stofferne i affald. Da det er en forordning, er reglerne umiddelbart gældende i alle EU-lande og skal ikke skrives ind i national lovgivning. Et par af de stoffer, der er kommet til siden sidste plan, er indtil videre ikke anvendelsesbegrænset under POP-forordningen men under EUs kemikalieforordning REACH, da POP-forordningen af tekniske årsager ikke har kunnet ændres. Forordningen er i øjeblikket under omarbejdning for blandt andet at adressere dette. Der er for en række af stofferne nogle undtagelser for anvendelsesbegrænsningen og dermed også et vedvarende arbejde med at vurdere, om disse undtagelser stadig er nødvendige. Dette arbejde foregår typisk på EU-plan og EU-kommissionen udarbejder også en implementeringsplan for hele EU.

POP-forordningen suppleres af en række andre forordninger, den danske miljøbeskyttelseslov og kemikalielov samt en række bekendtgørelser udstedt i medfør heraf. En meget stor del al lovgivningen er blevet opdateret siden udarbejdelsen af den foregående implementeringsplan.

En meget stor del af de aktuelle problemstillinger knytter sig til forekomsten af stofferne i affald og den rette håndtering af dette, til forurening af jord og grundvand og til den utilsigtede dannelse og udslip af POP-stoffer. For disse områder er det, bortset fra etablering af grænseværdier for affald i POP-forordningen, anden lovgivning, der sætter rammerne for håndteringen af POP-stofferne. På disse områder kan der være fortolkningsmæssige problemstillinger, eksempelvis i relation til forbrænding af materialer, der indeholder POP-stoffer.

De seks stoffer, som er kommet til siden sidste implementeringsplan

For de seks stoffer/stofgrupper, som er kommet til siden sidste implementeringsplan, indeholder rapporten en systematisk gennemgang af situationen i Danmark. I det følgende er der for hvert stof/stofgruppe givet en kort omtale af anvendelser og forbrug af stofferne, de vigtigste aktuelle problemstillinger og oplysninger om, i hvilken grad eksponering for stofferne i Danmark vurderes at finde sted og giver anledning til bekymring. For beskrivelse af andre områder henvises der til den mere omfattende beskrivelse i de stofspecifikke afsnit af rapporten.

Hexachlorbutadien (HCBD). HCBD har ligesom de øvrige POP-pesticider ikke været anvendt i Danmark i mange år, og det vurderes, at der i dag ikke findes lagre af gamle POP-pesticider i Danmark. Der vurderes ikke at være væsentlige aktuelle problemstillinger i relation til HCBD. Der findes meget få data for HCBD i fødevarer og drikkevand, men eksponeringen for HCBD vurderes på det foreliggende grundlag at være ubetydelig. Der vurderes ikke at være behov for yderligere initiativer i relation til HCBD.

Decabromdiphenylether (DecaBDE). DecaBDE har indtil for nylig været anvendt som flammehæmmer; primært i flammehæmmet plast i elektronik og byggematerialer og i tekstiler, som bl.a. har været anvendt i køretøjer. DecaBDE indgår i gruppen polybromerede diphenylethere (PBDE'er), og har historisk udgjort den største del af forbruget af PBDE'er.

I følge en massestrømsanalyse fra 1999 var forbruget i Danmark af bromerede flammehæmmere på daværende tidspunkt 332-660 tons; heraf 10-120 tons PBDE'er. Forbruget af decaBDE blev ikke særskilt opgjort, men udgjorde den største del. Den overvejende del af PBDE blev importeret med artikler. På det tidspunkt var decaBDE og andre PBDE'er stort set faset ud i produktion af plast til elektronik i Danmark af arbejdsmiljømæssige årsager, fordi decaBDE altid blev anvendt sammen med det kræftfremkaldende stof antimontrioxid, som blev brugt som synergistisk flammehæmmer. DecaBDE har siden 2008 været forbudt i elektriske og elektroniske produkter med visse undtagelser, som senere er ophævet. Der foreligger ikke nogen nyere opgørelser af forbruget i Danmark end 1999-opgørelsen.

Aktuelle problemstillinger vurderes primært at dreje sig om forekomsten af decaBDE i affald og i genanvendt plast. DecaBDE vil indgå i plastaffald fra skrotning af affald af elektriske og elektroniske produkter. I Danmark skal plast med bromerede flammehæmmere fra elektronik bortskaffes til virksomheder, der godkendt til at håndtere bromholdigt affald. Der sker stort set ikke nogen endelig behandling af elektronikaffald i Danmark, men der sker i et vist omfang en sortering af affaldet. Ved genanvendelse af flammehæmmet plast vil decaBDE, ifald der ikke sker en tilstrækkelig sortering af plasten, kunne indarbejdes i nye produkter. Undersøgelser har vist at decaBDE kan indgå i plast i importerede produkter fra genanvendelse af plasten uden for Danmarks grænser. DecaBDE i tekstiler i biler vil ende i shredderaffald. Problemstillingerne i relation til shredderaffald er nævnt nedenfor under PCB, som vurderes at være det mest problematiske POP-stof i shredderaffald og bestemmende for, hvordan affaldet håndteres. Destruktionseffektiviteten for decaBDE i affaldsforbrændingsanlæg omtales nedenfor sammen med omtalen af destruktion af andre POP-stoffer.
Den vigtigste eksponering for decaBDE er via fødevarer og med støv i indemiljøet. Den Europæiske Fødevaresikkerhedsautoritet (EFSA) vurderer, at indtag af decaBDE med fødevarer ikke giver anledning til bekymring i EU. Undersøgelser peger på, at eksponering fra støv kunne være den væsentligste eksponeringsvej, men da elektriske og elektroniske produkter indeholdende decaBDE i dag er mindst 14 år gamle, og dermed er ved at være udtjente, må denne eksponeringsvej regnes at være stærkt faldende.

Der er fire andre PBDE, som er optaget under konventionen, som blev indgående beskrevet i den seneste implementeringsplan. Disse indgik i de to kommercielle PBDE blandinger octaBDE (octabromdiphenylether) og pentaBDE (pentabromdiphenylether). Stofferne har været forbudt i mange år i EU, og produkter indeholdende stofferne vurderes stort set at være bortskaffede.

Nye initiativer. Nye initiativer vedrørende decaBDE og øvrige PBDE'er omfatter kontrol af produkter på det danske marked. MFVM vil desuden vurdere, hvordan materialer med PBDE'-er kan adskilles fra affaldsstrømmen før genanvendelse og anden affaldsbehandling og udarbejde vejledning til genanvendelsesvirksomheder.

Kortkædede chlorparaffiner (SCCP). Chlorparaffiner inddeles i tre grupper: kort-, mellem- og langkædede. Det er kun de kortkædede (SCCP), som er omfattet af Stockholmkonventionen. Anvendelse af SCCP er i dag forbudt, men der er en udtagelse for blandinger med et indhold op til 1% og i artikler med en koncentration op til 0,15%. Det betyder, at der eksempelvis i blandinger med mellemkædede chlorparaffiner (MCCP) kan være op til 1% SCCP som forurening. De 1% er den samme koncentration, som anvendes som grænseværdi for, hvornår materialer skal bortskaffes som farligt affald.

Der foreligger ingen samlet opgørelse af de aktuelle anvendelser i Danmark eller det samlede forbrug af SCCP med blandinger, hvor stofferne må indgå i koncentrationer på op til 1%. Det samlede forbrug af SCCP i blandinger med <1% SCCP registreret i Produktregistret i 2016 var 0,1 kg. Selvom Produktregistret kun omfatter professionelt brug tyder resultaterne på, at det aktuelle forbrug af SCCP med blandinger er meget begrænset. SCCP kunne indgå som urenhed i blandinger af mellemkædede chlorparaffiner (MCCP), som bl.a. anvendes i køle-/smøremidler og udfyldningsmidler.

Der er ikke fundet oplysninger om, hvilke artikler der vil kunne indeholde SCCP i koncentrationer på op til 0,15%. Det angives i baggrundsmateriale for begrænsningen i EU, at koncentrationen er sat ud fra den mængde SCCP, som er tilladt som urenhed i en artikel produceret med mellekædede chlorparaffiner (MCCP). MCCP er især importeret i artikler med PVC eller gummi, hvor stoffet er anvendt som blødgører.

Aktuelle problemstillinger vurderes primært at vedrøre forekomsten af SCCP i byggematerialer og i affald. SCCP vil primært kunne forekomme i affaldsstrømme i form af maling og fugemasser anvendt i bygninger og i gummi anvendt i køretøjer. Undersøgelser af forekomsten af SCCP i byggematerialer i forbindelse med renovering og nedrivning viste, at SCCP først og fremmest kunne findes i fugemasser, hvor SCCP blev fundet i 29% af de undersøgte fugemasser, som var udtaget fra bygninger fra den relevante periode. Af 170 fugeprøver med SCCP, havde de 115 en koncentration på mere end 1% og skulle dermed bortskaffes som farligt affald. Der blev ligeledes fundet SCCP i en koncentration på mere end 1% i en prøve af maling og i en klæber til gulvbelægning. Arbejdstilsynet har ikke udarbejdet anvisninger for arbejde med SCCP, men har angivet, at de samme anvisninger, som gælder for arbejde med PCB (polychlorerede biphenyler), vil være gældende for arbejde med SCCP. Da de absolutte koncentrationer af SCCP i materialerne svarer til koncentrationerne af PCB men grænseværdien for hvornår affald skal håndteres som farligt affald er 20 gange højere for SCCP end for PCB, er der ikke samme risiko for kontaminering af tilstødende materialer til niveauer over grænseværdien, som der er for PCB. Dermed må mængderne af bygningsaffald kontamineret med SCCP forventes at være langt lavere end det er tilfældet for PCB. Der synes ikke at være et indeklimaproblem i relation til SCCP.

Der er ingen overvågning af SCCP fødevarer i Danmark, men i følge EU's risikovurdering for SCCP giver eksponering af forbrugerne ikke anledning til bekymring.

Nye initiativer. MFVM vil evaluere behovet for yderligere information vedrørende identifikation og håndtering af SCCP-affald til entreprenører, ejendomsindehavere, kommuner og andre interessenter involveret i aktiviteter relateret til renovering og nedrivning af bygninger. Hvis evalueringen viser, at der er behov for yderligere information, vil MFVM udarbejde nødvendig vejledning.

Pentachlorphenol (PCP) blev tidligere anvendt til træbeskyttelse med et forbrug i midten af 1970'erne på 1,0-1,5 t/år. Det blev primært anvendt til overfladebehandling og er ikke rapporteret anvendt til sveller eller telefonpæle. PCP har ikke været anvendt i Danmark siden 1979, men blev først endeligt forbudt i 1996. PCP har også efter forbuddet kunnet forekomme i lave koncentrationer i visse typer af importeret træ f.eks. transportpaller.

Problemstillingerne har primært knyttet sig til forekomsten af dioxiner som forurening i PCP, og PCP-holdige materialer har tidligere har været en betydelig kilde til emissioner af dioxiner. Udslip af dioxiner fra imprægneret træ i brug og i importerede paller blev undersøgt i Danmark tilbage i 2004. Da PCP ikke har været anvendt til imprægnering i 40 år, må det forventes, at der næppe er meget træ imprægneret med PCP i brug i dag, og at de resulterende udslip af dioxiner er ubetydelige.

Indtaget af PCP med fødevarer er væsentligt under det tolerable daglige indtag, og eksponeringen af forbrugere til PCP giver ikke anledning til bekymring.

Der vurderes ikke at være behov for yderligere initiativer i relation til PCP.

Hexabromcyclododecan (HBCDD). HBCDD er indtil for nylig blevet anvendt som flammehæmmer til polystyrenskum (EPS og XPS) anvendt som isolering i bygge- og anlægssektoren, i plast i elektronik og i mindre grad i flammehæmmede tekstiler i bl.a. køretøjer. Det samlede forbrug i Danmark blev i 1999 opgjort til 26-80 t/år, heraf 13-36 t/år i byggematerialer. En nyere opgørelse fra 2014 angav, at forbruget med byggematerialer formodentlig var på samme niveau som i 1999, men der blev ikke foretaget en præcis kvantitativ opgørelse. Forbruget af HBCDD til produktion af EPS/XPS i Danmark havde imidlertid faldet fra et niveau på 6-13 t/år i 1999 til omkring 1 t/år i 2012.

I EU har langt den største anvendelse af HBCDD været til EPS ("flamingo") anvendt som isoleringsmateriale, men i Danmark har der typisk ikke været anvendt flammehæmmede kvaliteter, da materialet mest har været anvendt under terræn eller oven på betondæk, hvor der ikke var brug for flammehæmning. XPS har typisk været flammehæmmet, selvom det blev anvendt under terræn, hvor der ikke var behov for flammehæmning.

Problemstillingerne knytter sig primært til HBCDD i affald. Udtjent EPS og XPS fra byggeriet bliver typisk bortskaffet til affaldsforbrænding i anlæg til husholdningsaffald, og der foretages ikke en udsortering af affald med HBCDD. Undersøgelser tyder på, at stoffet bliver helt destrueret i affaldsforbrændingsanlæg til husholdningsaffald, men en svensk gennemgang af den eksisterende viden om destruktionseffektivitet vurderer, at datagrundlaget stadig er beskedent. Der er en igangværende dansk undersøgelse, som har til formål at afklare destruktionseffektiviteten af HBCDD, PBDE’er, SCCP og PFOS i danske anlæg.

Indtaget med fødevarer vurderes af den Europæiske Fødevaresikkerhedsautoritet (EFSA) at være under det tolerable daglige indtag, og eksponeringen af forbrugere for HBCDD anses ikke for at give bekymring. Med den anvendelse af flammehæmmet EPS og XPS der er sket i Danmark, vurderes der ikke at være nogen risiko for, at HBCDD fra isoleringsmaterialerne vil give anledning til forhøjede niveauer i indeluft.

Nye initiativer. På grundlag af en evaluering af effektiviteten af forbrænding af HBCDD i affaldsforbrændingsanlæg til husholdningsaffald vil MFVM vurdere, om udsortering med henblik på destruktion af EPS og XPS med HBCDD er påkrævet.

MFVM vil endvidere evaluere behovet for yderligere information til identifikation og håndtering af HBCDD-affald til entreprenører, ejendomsindehavere, kommuner og andre interessenter involveret i aktiviteter i forbindelse med renovering og nedrivning af bygninger. Hvis evalueringen viser et behov for yderligere information, vil MFVM udarbejde nødvendig vejledning

Polychlorerede naftalener (PCN). Der vurderes ikke at være problemstillinger knyttet til den tidligere, tilsigtede brug af PCN. Utilsigtet dannelse af PCN er nævnt under udslip af dioxiner og andre utilsigtet dannede POP-stoffer.

Stoffer omfattet af de foregående implementeringsplaner

For stoffer omfattet af de foregående implementeringsplaner henvises der til disse for en mere systematisk gennemgang af situationen i Danmark. Følgende beskriver kort, hvilke initiativer der er gennemført siden sidste plan, og hvad der vurderes stadig at være væsentlige problemstillinger for de pågældende stoffer.

PCB

Polychlorerede biphenyler (PCB) har været omfattet af konventionen fra dens ikrafttræden og er sammen med dioxiner de POP-stoffer, som der i Danmark har været de mest omfattende aktiviteter i forhold til. PCB har været reguleret i Danmark og i EU lang tid før Stockholmkonventionen trådte i kraft. Brug af PCB i åbne anvendelser som maling og fugemasse blev forbudt i Danmark i 1977 og senere fulgte i 1986 et forbud mod brug af PCB i elektrisk udstyr. Men materialer med PCB har vist sig at have en lang levetid, og der har de seneste 10 år været en øget opmærksomhed på PCB i materialer stadig i brug og de mulige sundhedsmæssige konsekvenser.

PCB i bygninger. Den foregående plan omtalte handlingsplanen for håndtering af PCB i bygninger fra 2011 som havde 19 initiativer, der er blevet gennemført i den efterfølgende periode. En kortlægning af PCB i bygninger fra PCB-perioden (1950-1977) viste, at en meget stor del af bygningsmassen indeholder materialer af PCB i koncentrationer over detektionsgrænsen. Det blev endvidere vist, at der var et stort antal bygninger, herunder skoler og daginstitutioner, der havde PCB i indeluft, som overskred Sundhedsstyrelsens anbefalede aktionsværdier. Som konsekvens af den udbredte forekomst af PCB i materialer, blev der i Affaldsdirektivet indført krav om kortlægning af PCB i bygninger fra PCB-perioden i forbindelse med renovering og nedrivning. Dette har resulteret i en kraftig stigning i mængderne af PCB-holdigt byggeaffald, som omtales nedenfor. Kortlægningen viste også en udbredt forekomst af PCB i små kondensatorer i lysstofarmaturer, og at disse, når de lækkede, kunne resultere i PCB koncentrationer i indemiljøet, der overskred de vejledende aktionsværdier. Som konsekvens har Miljøstyrelsen udarbejdet en vejledning om identifikation og håndtering af disse kondensatorer og har iværksat en kampagne med opfordring til at få udskiftet de gamle armaturer.

Som en følge af den øgede fokus på PCB i bygninger er de registrerede mængder af PCB-holdige byggematerialer steget fra omkring 50 t/år i 2007/2008 til 800 tons i 2011 og videre til 8.000 tons i 2014 jf. Miljøstyrelsens affaldsdatabasesystem. En del af stigningen skyldes, at der tidligere primært blev registreret affald der indeholdt over 50 mg/kg, der er grænsen for at affaldet defineres som farligt affald, mens en stor del af det affald, der er registreret de senere år, indeholder PCB i lavere koncentrationer.

Destruktion af PCB i affaldsforbrændingsanlæg. De store mængder affald med PCB i lavere koncentrationer har været baggrund for en række undersøgelser af, hvorvidt dette affald, for at nedbringe udgifterne til bortskaffelse, kunne forbrændes i affaldsforbrændingsanlæg til husholdningsaffald. Dette har resulteret i en del debat om bortskaffelsen af PCB-holdigt affald til disse anlæg. Samme overvejelser og debat har der været omkring forbrænding af shredderaffald, som indeholder PCB, som bl.a. stammer fra små kondensatorer. Der dannes hvert år 100.000-150.000 tons shredderaffald, og der er desuden deponeret 1,8 mio. tons shredderaffald. PCB-indholdet i nyt affald er i gennemsnit lidt lavere end grænseværdien på 50 mg/kg, mens den i deponeret affald er omkring grænseværdien. Det samlede indhold af PCB i deponeret affald kan groft beregnes til ca. 90 tons. Dette affald vil også indeholde andre POP-stoffer - især PBDE'er og PFOS. Der er politisk interesse for at brænde shredderaffald for at udnytte affaldets energiindhold og rykke behandling af shredderaffald længere op i affaldshierakiet (fra deponering til forbrænding med energigenvinding). De høje værdier for PCB i nyt shredderaffald kunne tyde på, at kondensatorer i udstyr ikke i tilstrækkelig grad fjernes fra udstyret inden det shreddes. En litteraturundersøgelse af destruktionseffektiviteten i forbrændingsanlæg til husholdningsaffald fandt, at destruktionseffektiviteten i de pågældende anlæg var i størrelsen 90-99%, mens hovedparten af det øvrige indhold blev fanget ved røggasrensningen, mens i størrelsen 1% blev udledt med røggassen. Undersøgelsen nævner dog, at det er vanskeligt at ekstrapolere fra de foreliggende undersøgelser til danske anlæg i brug i dag. Til sammenligning anbefales i vejledninger til Basel- og Stockholmkonventionen en destruktionseffektivitet på >99.999% for affald med en PCB-koncentration på >50 mg/kg.

PCB i elektrisk udstyr. Store PCB-holdige apparater med > 500 mg/kg skulle have været bortskaffet eller dekontamineret i Danmark 1. januar 2000. Der ses stadig store mængder af affald af kondensatorer og transformatorer med mindre end 50 mg/kg. For perioden 2011-2016 varierede mængderne fra omkring 50 t/år til 580 t/år. Miljøstyrelsen har igangsat en undersøgelse af forekomst og håndteringen af PCB i større transformatorer og kondensatorer i Danmark. De foreløbige resultater indikerer, at store transformatorer med mere end 500 mg/kg PCB er blevet bortskaffet, samt at omkring 98% af mængderne fra danske producenter af affald er transformatorer med mindre end 50 mg/kg PCB, som håndteres af virksomheder, der har godkendelse til at håndtere dette udstyr. Ca. 2% bortskaffes som farligt affald. Undersøgelsen er ikke færdig, og de detaljerede oplysninger om håndteringen af PCB-holdigt udstyr og transformatorolier er ikke færdigvurderet.

PCB i fødevarer. Forekomsten af PCB i fødevarer giver stadig anledning til bekymring. PCB i fødevarer stammer primært fra fisk, mejeriprodukter, fedt og kød. Indtaget af PCB med fødevarer er faldet til ca. ¼ af niveauet i 1970'erne. Ved overvågningen skelnes der mellem de dioxinlignende PCB, som er beskrevet nedenfor sammen med dioxinerne, og de ikke-dioxinlignende PCB. For de ikke-dioxinlignende PCB er det op til 1-5% af befolkningen, der har et indtag over det tolerable ugentlige indtag. I Danmark kommer det største bidrag fra fisk og fiskeprodukter (ca. 32%) fulgt af mejeriprodukter, fedt og fedtprodukter samt kød og kødprodukter.

PCB i indemiljøet. Den foregående implementeringsplan omtalte målinger af PCB i blod fra beboere af lejligheder med højt indhold af PCB i materialer, og at Sundhedsstyrelsen anbefalede, at der blev foretaget flere undersøgelser, som inkluderer både indeklima og blodanalyser med henblik på at få de foreliggende undersøgelsesresultater belyst i en national sammenhæng. De udførte undersøgelser viste, at indholdet af ikke-dioxinlignende-PCB i blodet var ca. 3 gange højere i personer, der var eksponerede i indemiljøet i forhold til en kontrolgruppe, mens det for de dioxinlignende PCB var ca. dobbelt så højt. Det blev vurderet, at der ikke umiddelbart ville være akutte helbredseffekter. Men ved eksponering i indemiljøet bliver man i særlig grad eksponeret for PCB med en lav chloreringsgrad, hvis mulige effekter er mindre undersøgt. Der er derfor igangsat et større forskningsprojekt, HESPERUS, med deltagelse af en række forskningsinstitutioner i Danmark og udlandet med henblik på at undersøge de helbredsmæssige effekter af at leve i boliger eller opholde sig i institutioner med PCB i indemiljøet. Projektet undersøger bl.a. de mulige effekter af de lavtchlorerede PCB congenerer[3], og sammenholder for et stort antal personer viden om mulig eksponering i indemiljøet med en række forskellige helbredseffekter.

Nye initiativer. MFVM vil afslutte den igangværende undersøgelse af PCB i transformatorer og kondensatorer og evaluere, i hvilket omfang yderligere initiativer er nødvendige.

Resultaterne af det igangværende HESPERUS-projekt, som vurderer risikoen af lavtchlorerede PCB i indemiljøet, vil blive fulgt og det vil vurderes i hvilket omfang yderligere handlinger vil være påkrævet som følge af projektets resultater.

MFVM vil revurdere destruktionseffektiviteten for PCB i forbrændingsanlæg til husholdningsaffald sammen med resultater af en igangværende vurdering af effektivitet for andre POP-stoffer. På dette grundlag vil ministeriet vurdere behovet for yderligere initiativer.

PFOS

PFOS anvendes i denne sammenhæng som samlebetegnelse for perfluoroctansulfonsyre og dets salte samt stoffet perfluoroctansulfonyl fluorid, PFOSF. Generelt har undersøgelser i Danmark, både hvad angår anvendelserne af PFOS i samfundet, human eksponering eller PFOS i miljøet omfattet flere stoffer inden for stofgruppen af per- og polyfluorakylstoffer (PFAS). Andre PFAS stoffer er ligesom PFOS persistente og to andre PFAS - PFHxS (perfluorhexansulfonsyre) og PFOA (perfluoroctansyre) - er under vurdering for optagelse under konventionen. Ved en vurdering af mulige effekter af stofferne bør der ses på den samlede belastning fra stofferne, og eksponering for PFOS udgør kun en del af det samlede billede.

Tilsigtede anvendelser. Der er i POP-forordningen en undtagelse for anvendelse af PFOS til ikke-dekorativ hårdforkromning, og PFOS har indtil for få år siden været anvendt til dette formål i Danmark. Danmark har notificeret konventionens sekretariat om brug af PFOS til denne anvendelse. Denne anvendelse er i dag ophørt, da PFOS er blevet erstattet af en kortere-kædet PFAS. Til andre anvendelser har PFOS ikke været tilsigtet anvendt i mange år og for-

[3] Både PCB, dioxiner, furaner og PBDE'erne består af en række stoffer, såkaldte congenerer, som karakteriseres ved antallet af chloratomer og chloratomernes placering i molekylet. De forskellige congenerer har forskellig giftighed og forskellige fysiske og kemiske egenskaber, der har betydning for, hvordan de spredes i indemiljøet og i miljøet.

ventes stort set at være ude af affaldsstrømmen. PFOS kan optræde som urenhed i blandinger af PFAS, men de undersøgelser, der er foretaget i Danmark af PFAS i børnetøj, gulvtæpper til børneværelser og fødevareemballager af pap og papir, har ikke fundet PFOS i koncentrationer over de tilladte koncentrationer i POP-forordningen.

Artikler indeholdende PFOS vil, når de bliver til affald, typisk bortskaffes til affaldsforbrænding. Tilgængelige resultater tyder på, at der ved affaldsforbrænding i anlæg til husholdningsaffald sker en tilstrækkelig nedbrydning af stofferne, men det angives af eksperter, at der stadig er stor usikkerhed om dette. Som nævnt er der en dansk vurdering under udarbejdelse.

Indtag med fødevarer. Indtag af PFOS med fødevarer vurderes af DTU Fødevareinstituttet at være under det tolerable daglige indtag. Dette er baseret på indtag af fisk, der generelt vurderes at være den største kilde. Der er et særligt fokus på anvendelsen af PFAS i pap og papir der anvendes til fødevareemballage og eksponering fra disse. Fødevarestyrelsens analyser af fødevareemballager af pap og papir har ikke fundet PFOS og ni andre perfluoralkyl sulfonsyrer (PFSA), og stoffer der kan nedbrydes til PFSA, i koncentrationer over detektionsgrænsen. Det er dog kun meget få PFAS, der indgår i analysen. Fødevarestyrelsen fraråder brugen af PFAS i pap- og papiremballage til fødevarer og har fastsat en indikatorværdi på 10 µg totalt organisk fluor pr. dm^2 papir.

Jord- og grundvandsforurening. Den vigtigste aktuelle problemstilling i relation til PFOS er forekomsten som jord- og grundvandsforurening på arealer, der bliver anvendt til brandøvelser, hvor der tidligere blev anvendt PFOS-holdigt brandslukningsskum. PFOS har typisk været anvendt i blandinger med andre PFAS og undersøgelser har omfattet en række PFAS. Denne type brandslukningsskum har mest været anvendt til slukning af oliebrande og det er derfor anvendt i særlig grad på brandøvelsespladser nær lufthavne. Der er fundet relativt høje koncentrationer i jord og grundvand på de undersøgte brandøvelsespladser og på en enkelt plads var koncentrationerne så høje, at der er etableret afværgeforanstaltninger. Det er endvidere vist i screeninger af grundvandsmagasiner, at prøver taget nær brandøvelsespladser indeholdt målbare koncentrationer af PFOS. Der er desuden fundet PFOS i jord og grundvand i forbindelse med en tæppefabrik, hvor PFOS-holdige imprægneringsmidler har været anvendt. Ved en screeningsundersøgelse fra 2014 blev der fundet PFAS på halvdelen af de undersøgte lokaliteter i koncentrationer over eller på niveau med de danske kriterier for PFAS i drikkevand og grundvand. Der er ikke foretaget en vurdering af den sundhedsmæssige betydning af disse overskridelser. En skrivebords-undersøgelse har peget på andre steder, hvor der potentielt kan være forurening med PFOS og andre PFAS fra tidligere anvendelser af PFOS-holdige blandinger. Det drejer sig bl.a. forkromningsindustri, tekstilindustri og malingsindustri.

Nye initiativer. Idet PFOS ikke længere anvendes i skumdæmpende midler til ikke-dekorativ hårdforkromning, vil Danmark trække notifikationen af denne anvendelse tilbage. Desuden vil Danmark informere Stockholmkonventionens sekretariat og EU-kommissionen om erfaringerne med substitution af PFOS til denne anvendelse.

Naturstyrelsen har i 2014 givet instrukser til kommunerne om kontrol af PFAS i drikkevand på steder, hvor anvendelse af PFOS og andre PFAS har fundet sted. I 2018 har Regionernes Videncenter for Miljø og Ressourcer publiceret en håndbog om undersøgelse og afværge af forurening med PFAS-forbindelser. Der vurderes derfor ikke at være behov for, at der tages yderligere initiativer fra MFVM i relation til jord- og grundvandforurening med PFAS på nuværende tidspunkt.

MFVM vil vurdere behovet for yderligere initiativer, når en undersøgelse om destruktion af PFOS og andre POP-stoffer i forbrændingsanlæg til husholdningsaffald er færdiggjort.

Dioxiner[4] og andre utilsigtet dannede POP-stoffer

Udslip af dioxiner. Dioxiner har aldrig været produceret tilsigtet, men dannes utilsigtet ved en række industrielle kemiske processer og forbrændingsprocesser. Udslip af dioxiner fra forbrændingsanlæg og industri er i Danmark faldet til under 5% af niveauet i 1990'erne, bl.a. som konsekvens af indførelse af en grænseværdi for udslip af dioxiner på EU-niveau. De væsentligste kilder til dioxinudslip er i dag, ligesom det var ved udarbejdelsen af den foregående plan, afbrænding af biomasse i brændeovne og mindre fyringsanlæg samt brande og bål. Brændeovne og andre mindre fyringsanlæg står således for omkring 60% af de samlede udslip. Bedre fyringsteknikker, som kan mindske udslip af partikler og PAH (polyaromatiske hydrocarboner) fra brændeovne, har desværre vist sig ikke at have en virkning på udslip af dioxiner. I de nationale opgørelser af udslip af dioxiner regnes der med tre typer af brændeovne, og det antages, at de nyeste miljømærkede brændeovne har væsentligt mindre udslip end de gamle. Brændeovnsbekendtgørelsen fastsætter ikke regler for udslip af dioxiner i forbindelse med typegodkendelse af brændeovne. Gamle ovne med høje emissioner udgør stadig mere end halvdelen af ovnene, og dermed langt den største del af de beregnede emissionerne. I følge disse opgørelser vil emissionerne på sigt mindskes ved udskiftning af gamle ovne med nye. Nyere danske undersøgelse kan dog ikke bekræfte, at udslippene generelt er væsentlig lavere i de nye ovne, men peger på at brændets sammensætning formodentlig har større indflydelse på dannelsen af dioxiner.

Sæsonvariationer i koncentrationen af dioxiner i luften over Østersøen peger på, at ikke-industrielle forbrændingsprocesser formentlig er de væsentligste kilder. Modelberegninger fra 2012 når frem til, at 49% af den atmosfæriske deposition af dioxin til Bælthavet stammer fra danske kilder, mens danske kilder udgør 41% af den atmosfæriske deposition til Kattegat. For andre farvandsområder i Østersøregionen er bidraget fra danske kilder lavt.

Dioxiner i røggasrensningsprodukter. I de foregående implementeringsplaner er dannelse af dioxiner i forbrændingsanlæg blevet belyst. Med forbedring af dioxinrensningen er udledningerne til luft blevet reduceret, så forbrændingsanlæg kun udgør en lille del af de samlede udledninger af dioxiner. Men samtidig er en større del af de dannede dioxiner endt i restprodukterne fra røggasrensningen. Den foregående implementeringsplan havde således en aktion, der vedrørte at undersøge mulighederne for bedre behandling af røggasrensningsprodukter. Røggasrensningsprodukter fra affaldsforbrændingsanlæg for husholdningsaffald bliver dog stadig eksporteret til deponering i et udtjent kalkbrud i Norge eller i nedlagte saltminer i Tyskland. Der er for øjeblikket et projekt under udførelse (HALOSEP), som undersøger mulighederne for at behandle røggasrensningsprodukterne på en måde, så eksport og deponering af røggasrensningsprodukterne kan reduceres.

Dioxiner i fødevarer. Forekomsten af dioxiner i fødevarer giver stadig anledning til bekymring. Ved monitering i fødevarer måles dioxinerne sammen med de dioxin-lignende PCB og angives med et samlet mål for dioxintoksiciteten. Indholdet af dioxiner og dioxin-lignende PCB i visse animalske fødevarer er stadig højt. Der er indført krav om risikostyringsforanstaltninger ved markedsføring af visse fiskearter fanget i Østersøen og tilstødende farvande pga. for højt indhold af disse stoffer. Herudover er der fundet høje niveauer i æg fra fritgående høns fra nogle bedrifter og i hestekød, så Fødevarestyrelsen anbefaler bl.a., at forbrugere begrænser indtaget af laks fra Østersøen, torskelever, hestekød, og lever fra får og råvildt samt at forbrugere køber æg fra forskellige besætninger. Eksponeringen for dioxiner og dioxinlignende PCB er primært gennem fødevarer. Fisk står for det største bidrag (31%) fulgt af mejeriprodukter og kød, mens æg bidrager med mindre end 5%. Den Europæiske Fødevaresikkerheds Autoritet

[4] "Dioxiner" anvendes her som fællesbetegnelse for gruppen af Polychlorerede dibenzo-p-dioxiner (PCDD) og polychlorerede dibenzofuraner (PCDF). Koncentrationen af disse angives normalt samlet omregnet til et mål for stoffernes dioxintoksicitet (i enheden TEQ).

(EFSA) har november 2018 sænket det tolerable ugentlige indtag (TWI) for dioxiner of dioxin-lignende PCB, hvilket indebærer at befolkningens gennemsnitlige eksponering for disse stoffer er næsten to gange den nye anbefalede TWI. Der er dog stadig nogen uklarhed vedrørende toksiciteten af en af de betydende PCB congenerer, som har indflydelse på vurderingen. Fødevarestyrelsen har december 2018, som konsekvens af den lavere TWI, ændret styrelsens anbefalinger til forbrugerne.

Svenske undersøgelser af kilder til dioxiner i sild i Østersøen når frem til at forbrændingsprocesser formentlig er de væsentligste kilder, men undersøgelserne har ikke vurderet, i hvilken grad frigivelse af dioxiner, som er ophobet i sedimenterne fra historiske udledninger, bidrager til den aktuelle forekomst af dioxiner i fiskene.

Andre utilsigtet dannede POP-stoffer. De øvrige utilsigtet dannede stoffer, som er omfattet af Stockholmkonventionen, er PCB, hexachlorbenzen (HCB), pentachlorbenzen, HCBD og polychlorerede naftalener (PCN). Af disse findes der udslipsopgørelser for HCB og de dioxin-lignende PCB. For HCB er de vigtigste kilder affaldsforbrændingsanlæg og dieseldrevne køretøjer. Niveauet har været konstant i mange år, men udslip var i begyndelsen af 1990'erne, da HCB stadig forekom i pesticider, ca. 10 gange større. HCB overvåges i fødevarer sammen med andre chlorerede pesticider. Indtaget med fødevarer er generelt for disse pesticider under de toksikologiske referenceværdier. Kilderne til utilsigtet dannede dioxin-lignende PCB er først og fremmest dieseldrevne køretøjer. Der er set en svagt stigende tendens i udslippene de seneste 20 år. Før denne tid var udslippene ca. 5 gange større fordi benzinbiler, der anvendte blyholdig benzin, havde et stort udslip. Der findes ingen opgørelser af udslip til miljøet af tilbageværende PCB i byggematerialer og elektrisk udstyr.

Nye initiativer. Gennemførte undersøgelser tyder på, at dannelse og emission af dioxiner fra brændeovne er væsentligt lavere, når der brændes rent ved. MFVM vil ved kommende informationskampagnes informere brugerne om at brænde rent og tør træ, og undgå at brænde affald.

Da der endnu ikke findes opgørelser af udslip af utilsigtet dannet HCBD og PCN, vil der udarbejdes screeningsundersøgelser af emissioner af disse stoffer.

Fremdriften af det igangværende HALOSEP-projekt vil blive fulgt, og MFVM vil på grundlag af resultaterne vurdere, om der skal igangsættes yderligere aktiviteter, og om der skal foretages ændringer i lovgivningen vedrørende bortskaffelse af røggasrensningsprodukter.

Særligt eksponerede befolkningsgrupper

Der vil kunne være eksponering for POP-stofferne i arbejdsmiljøet i tilknytning til en række processer. I byggeriet vil arbejdere kunne eksponeres for PCB og SCCP i forbindelse med renoveringer og nedrivninger og der er udarbejdet vejledninger om håndtering af materialer indeholdende stofferne. Der vil også ved renovering og nedrivning kunne ske eksponering for HBCDD i isoleringsmaterialer, men EU-risikovurderingen for HBCDD vurderer, at eksponeringen ved disse aktiviteter vil være ubetydeligt i relation til andre eksponeringer. Udenlandske undersøgelser har påvist betydelig eksponering for PBDE'er ved behandling af elektronikaffald, men det forgår i dag kun en meget begrænset behandling af elektronikaffald i Danmark. Der vil kunne være en vis eksponering for dioxiner og andre POP-stoffer i forbindelse med kilder til dannelse af disse stoffer. Udenlandske undersøgelser af skorstensfejere og ansatte på forbrændingsanlæg har ikke fundet eksponeringsniveauer væsentlig over den almindelige befolkning. En britisk undersøgelse af arbejdsmiljøeksponering til dioxiner i en række sektorer fandt, at især sekundærproduktion af aluminium og stål fra skrot gav anledning til væsentlige eksponeringer, men en sådan produktion finder ikke sted i Danmark.

Kvinder i den fødedygtige alder, gravide og ammende er særlig risikogruppe, fordi POP-stoffer kan overføres til fostre og nyfødte, som er særligt følsomme over for effekter af POP-stoffer. Det anbefales derfor, at disse grupper begrænser indtaget af visse typer af fisk og andre fødevarer med højt indhold af POP-stoffer.

Andre aktiviteter

Landebasislinjen indeholder oplysninger om programmer for monitering af POP-stofferne, information til befolkningen, aktiviteter af NGO'er, mm. For disse afsnit henvises der til selve rapportteksten.

Sammenfatning

Nye initiativer og aktiviteter til Danmarks videre implementering af Stockholmkonventionen er sammenfattet i nedenstående tabel.

TABEL 1 Nye initiativer og aktiviteter til Danmarks videre implementering af Stockholmkonventionen.

Stof/område	Nr	Initiativer
DecaBDE og andre PBDE'-er	1	Kontrolprojekt af produkter på det danske marked. Vurdere, hvordan materialer med PBDE'er kan adskilles fra affaldsstrømmen før genanvendelse og anden affaldsbehandling. Udarbejde vejledning til genanvendelsesvirksomheder
SCCP	1	Evaluere behovet for yderligere information om identifikation om SCCP-affald til entreprenører, ejendomsindehavere, kommuner og andre interessenter involveret i aktiviteter relateret til renovering og nedrivning af bygninger. Hvis evalueringen viser, at der er behov for yderligere information, udarbejder MFVM dette.
HBCDD	1	På grundlag af en evaluering af effektiviteten af forbrænding af HBCDD i forbrændingsanlæg til dagrenovation vil MFVM vurdere, om udsortering med henblik på destruktion af EPS og XPS med HBCDD er påkrævet.
	2	Evaluere behovet for yderligere information til identifikation og håndtering af HBCDD-affald til entreprenører, ejendomsindehavere, kommuner og andre interessenter involveret i aktiviteter i forbindelse med renovering og nedrivning af bygninger. Hvis evalueringen viser et behov for yderligere information, udarbejder MFVM dette.
PCB	1	Afslut igangværende undersøgelse af PCB i transformatorer og kondensatorer og evaluere, i hvilket omfang yderligere initiativer er nødvendige.
	2	Følg resultaterne af det igangværende HESPERUS-projekt, som vurderer risikoen af lavtchlorerede PCB i indemiljøet. Vurdere i hvilket omfang yderligere handlinger vil være påkrævet som følge af projektets resultater.
	3	Revidere vurderingen af destruktionseffektiviteten for PCB i forbrændingsanlæg til husholdningsaffald sammen med resultater af den løbende vurdering af effektivitet for andre POP-stoffer. Vurder på dette grundlag behovet for yderligere initiativer.
PFOS	1	Tilbagetrækning af notifikation af brug af PFOS i skumdæmpende middel til ikke-dekorativ hårdforkromning. Desuden vil Danmark informere Stockholmkonventionens sekretariat og EU-kommissionen om erfaringerne med substitution af PFOS til denne anvendelse.
	2	Vurdere behovet for yderligere initiativer, når en undersøgelse om destruktion af PFOS og andre POP-stoffer i forbrændingsanlæg til dagrenovation er færdiggjort
Dioxiner og andre utilsigtet dannede POP-stoffer	1	Informere brugere om de skal bruge rent og tørt træ og ikke må afbrænde affald i brændeovne i kommende kampagner om at fyre fornuftigt.
	2	Udarbejde screeningsundersøgelser for emissioner af HCBD og PCN.
	3	Fremdriften af HALOSEP-projektet vil blive fulgt, og det vil på grundlag af resultaterne blive vurderet, om der skal igangsættes yderligere aktiviteter, og om der skal foretages ændringer i lovgivningen vedrørende bortskaffelse af røggasrensningsprodukter.

1. Introduction

1.1 Denmark's updated plan for implementation of the Stockholm Convention

1.1.1 Background and objectives of the implementation plan

The Stockholm Convention on Persistent Organic Pollutants was adopted in May 2001 and entered into force on 17 May 2004. The purpose of the Convention is to protect human health and the environment against persistent organic pollutants, also called POPs.

Denmark's instrument of ratification was deposited with the Secretary-General of the United Nations on 17 December 2003. Upon ratification, Denmark notified the Secretary-General of the territorial exclusion with respect to the Faroe Islands and Greenland. The exclusion with respect to the Faroe Islands was withdrawn effective as of the second half of 2012.

The Convention was notified in Denmark by Statutory Order no. 29 of 14 October 2004 of the Ministry of Foreign Affairs of Denmark.

In 2006 Denmark submitted a national implementation plan (NIP) to the Conference of the Parties describing the POP situation in Denmark and plans to implement Denmark's obligations under the Convention. An updated implementation plan was submitted in 2012.

The objectives of this implementation plan are:

- To inform the Stockholm Convention secretariat about Denmark's implementation of its obligations under the Convention;
- To provide background information for authorities and other stakeholders in Denmark about the current issues regarding POPs in Denmark;
- To facilitate public participation in the process of developing activities, strategies and action plans for further reduction of environmental and health risks of POPs in Denmark;
- To inform the European Commission and other EU Member States as well as other parties to the Convention about the key POPs issues in Denmark and measures for risk reduction.

1.1.2 Preparation and adoption of the implementation plan

This updated implementation plan was prepared by the Ministry of Environment and Food of Denmark (MFVM). The work was followed by an advisory group comprising representatives from the following organisations:

- Ministry of Environment and Food of Denmark (MFVM)
- Danish Environmental Protection Agency
- Danish Veterinary and Food Administration
- Danish Health and Medicines Authority
- Danish Transport, Construction and Housing Authority
- Central Organisation of Industrial Employees in Denmark (CO-industri)
- United Federation of Danish Workers (3F)
- Danish Society for Nature Conservation
- Confederation of Danish Industry
- Danish Chamber of Commerce

- Ecological Council
- Danish Consumer Council TÆNK
- Aarhus University, Center for Energy and Environment (DCE)
- National Association for Information on Wood Stove Pollution (LOB)
- Dakofa, Waste and Resource Network Denmark.

The work was managed and coordinated by a steering group from the Department of the Ministry of Environment and Food of Denmark. Assistance with the drafting was provided by the consulting company COWI.

Work was carried out in the following steps:
- Preparation of an updated introduction and country baseline,
- Evaluation of actions from previous action plans,
- Compilation of strategy elements and action plans and completion of draft implementation plan,
- Consultation of stakeholders, and
- Completion of the final implementation plan.

1.1.3 Structure of the implementation plan

The updated implementation plan follows the same structure as the implementation plans from 2006 and 2012, both of which followed a structure proposed by the Secretariat of the Stockholm Convention.

After a short *introduction* which is primarily a reading guide describing why and how the implementation plan was prepared, *Chapter 2* describes the *country baseline*. The description is introduced by a country profile briefly describing Denmark for external readers. Compared with the 2006 and 2012 implementation plans this part has been shortened; reference is made to the 2012 implementation plan for a further description. The following section describes the institutional, political and regulatory frameworks focusing on the individual institutions and their areas of responsibility in relation to POPs, as well as how the POP issues are connected to other environmental policy priorities. The subsequent sections describe other relevant international obligations and existing legislation on POPs.

Chapter 2 also reports the assessment of POPs issues in Denmark, forming the basis for later strategy and action plan elements. For the 22 substances specified in detail in the previous plans, the current plan focuses on describing developments in the past six years. In relation to the six new substances, the plan briefly describes former and current uses, releases and the presence of the POPs in the environment, food, animal feed, waste and contaminated sites to give an impression of the extent of the problems. The plan also describes the activities of monitoring POPs and research on impacts on humans and the environment. Vulnerable population groups are mentioned in a short section.

Chapter 3 describes point-by-point *strategies and action plan elements* to achieve compliance with Denmark’s obligations under the Convention. Each section includes a summary of the provisions in the Convention text applicable to the relevant area, a brief description of current issues and a description of ongoing and planned initiatives in the area.

1.2 The Stockholm Convention

The Stockholm Convention was adopted in May 2001 and entered into force on 17 May 2004. It promotes global action on persistent organic pollutants (POPs), with an overall objective to protect human health and the environment from POPs and requires Parties to take measures to eliminate or reduce the release of POPs into the environment. As of August 2018, the Convention had been adopted by 182 parties.

At the sixth, seventh and eighth meetings of the Conference of the Parties in 2013, 2015 and 2017, respectively, a total of six new substances or substance groups were added to the Convention. An important part of this updated implementation plan relates to these new substances.

Substances under the Stockholm Convention are divided into three groups, each of which is listed in its own Annex to the Convention:

Annex A:	Substances Parties must ban[5]
Annex B:	Substances Parties must restrict
Annex C:	Substances formed unintentionally, the formation of which Parties must restrict or, if possible, eliminate

The Stockholm Convention also foresees identification and safe management of stockpiles and wastes containing or consisting of POPs. Waste consisting of or contaminated with POPs should be disposed of in such a way that the POP contents are destroyed or irreversibly transformed so that they do not exhibit the characteristics of POPs. Where destruction or irreversible transformation does not represent the environmentally preferable option or the POPs content is low, waste should be disposed of in an environmentally sound manner.

Disposal operations that may lead to recovery, recycling or direct reuse of POPs are explicitly forbidden.

The Convention stipulates a number of general obligations, including that Parties are to regularly update the implementation plan in accordance with the decisions adopted by the Conference of the Parties.

Furthermore, where appropriate, Parties must cooperate directly or through global, regional and sub-regional organisations. They must consult their national stakeholders, including women's groups and groups involved in the health of children, in order to facilitate the development, implementation and updating of their implementation plans.

Finally, Parties must endeavour to utilise and establish the means to integrate national implementation plans for persistent organic pollutants in their sustainable development strategies where appropriate.

1.3 POPs covered by the Convention, the POP Protocol and the POP Regulation

POPs substances are chemical substances that persist in the environment, bioaccumulate through the food web, and pose a risk of causing adverse effects to human health and the environment. Characteristic for the substances listed under the Convention is that they are also transboundary pollutants, i.e. the activities in one country may have an influence on the regional or global environment.

The EU has implemented the provisions of the Stockholm Convention in Regulation (EC) no. 850/2004 on persistent organic pollutants (the POP Regulation), mentioned in section 2.2.5. The POP Regulation implements all of the provisions of the Convention along with other legislation, also mentioned in section 2.2.5.

POPs are also covered by the UNECE POP Protocol, a protocol to the 1979 Convention on Long-range Transboundary Air Pollution (CLRTAP), further described in section 2.2.4. The

[5] Time-limited exemptions for specific uses can be provided under the Convention.

protocol covers a number of POPs; most are the same as those covered by the Stockholm Convention. The provisions of the POP Protocol have been implemented in the POP Regulation, supplemented by other legislation.

Like the Stockholm Convention, the POP Protocol and the POP Regulation list substances in three annexes comprising elimination (Annex I), restriction (Annex II) and restriction or elimination of unintentional production (Annex III).

TABLE 1 provides an overview of the POPs covered by the Stockholm Convention, the POP Protocol and the POP Regulation, respectively. The substances are divided into old substances under the Stockholm Convention, new substances under the Convention and other substances which are only covered by the POP Protocol and the POP Regulation.

Two of the substances, decaBDE and PCP, are not yet included in the Annexes to the POP Regulation but are listed in Annex XVII to REACH and thereby restricted in the EU. Furthermore, another group of compounds, PCNs, is also under preparation for listing in Annex III under the POP regulation.

TABLE 2. Substances covered by the Stockholm Convention, the UNECE POP Protocol and the POP Regulation indicating the annexes in which the substances are listed

Substance	CAS no.	The Stockholm Convention	The POP Protocol	The POP Regulation
Old substances (covered by the previous NIP)				
Aldrin	309-00-2	A	I	I
Chlordane	57-74-9	A	I	I
Chlordecone	143-50-0	A	I	I
DDT	50-29-3	B	I, II**	I
Dieldrin	60-57-1	A	I	I
Endrin	72-20-8	A	I	I
Heptachlor	76-44-8	A	I	I
Hexabromobiphenyl (hexaBB)	36355-01-8	A	I*	I
Hexabromodiphenyl ether and heptabromodiphenyl ether	68631-49-2 207122-15-4 446255-22-7 207122-16-5 and others	A	I*	I
Hexachlorobenzene (HCB)	118-74-1	A, C	I, III	I, III
Lindane (γ-HCH)	58-89-9	A	I*	I
Mirex	2385-85-5	A	I	I
Pentachlorobenzene	608-93-5	A, C	Not included	I, III
Perfluorooctane sulfonic acid and its derivatives (PFOS), its salts, and perfluorooctane sulfonyl fluoride (POSF)	Many different	B	I, II *, **	I Perflouroctane sulfonate and its derivatives incl. polymers (PFOS)
Polychlorinated biphenyls (PCB)	Many different	A, C	I, II	I

Substance	CAS no.	The Stockholm Convention	The POP Protocol	The POP Regulation
Polychlorinated dibenzofurans (PCDF)	Many different	C	III	III
Polychlorinated dibenzo-p-dioxins (PCDD)	Many different	C	III	III
Technical endosulfan and its related isomers	959-98-8 33213-65-9 115-29-7 1031-07-8	A	Not included	I
Tetrabromodiphenyl ether and pentabromodiphenyl ether	40088-47-9 32534-81-9 and others	A	I *	I
Toxaphene	8001-35-2	A	I *	I
α -HCH	319-84-6	A	I	I
β-HCH	319-85-7	A	I	I
New substances (added since last NIP)				
Decabromodiphenyl ether (commercial mixture, c-decaBDE)	1163-19-5	A	Not included	***
Hexachlorobutadiene (HCBD)	87-68-3	A, C	I *	I
Hexabromocyclododecane (HBCDD)	3194-55-6 25637-99-4	A	Not included	I
Short-chain chlorinated paraffins (SCCPs)	85535-84-8	A	I , II *,**	I
Pentachlorophenol (PCP) and its salts and ester	87-86-5 and others	A	Not included	****
Polychlorinated naphthalenes (PCNs)	70776-03-3	A, C	I *	I
Other substances not covered by the Stockholm Convention				
Polyaromatic hydrocarbons (PAH)	Many different	Not included	III	III

* The substances have been added to the annexes but the supplement has not yet entered into force (August 2018) because the amendments have not yet been ratified by two-thirds of the Parties.

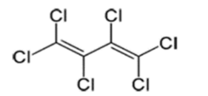
** The substances are listed in Annex II for specific uses exempt under certain conditions.

*** The substance is not listed in Annex I to the POP Regulation but is listed in REACH Annex XVII (Entry 67) and, with a few exceptions (mainly use in aircrafts), (Commission Regulation (EU) 2017/227). The manufacture or placing on the market of the substance is thereby banned effective from 2 March 2019 as a substance on its own, in another substance, as a constituent, as a mixture or in an article in concentrations exceeding 0.1 % by weight.

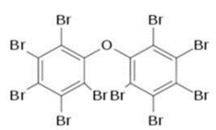
**** The substance is not listed in Annex I to the POP Regulation but is listed in REACH Annex XVII (Entry 22)

1.3.1 The newly added POPs

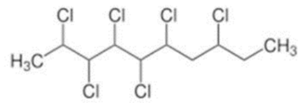
Substances listed in the Annexes to the Stockholm Convention in 2013, 2015 and 2017 are designated "the newly added POPs" in this context. The website of the Stockholm Convention uses the term “new POPs" for all substances added after the Convention went into force.



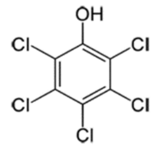
Hexachlorobutadiene (HCBD) is an aliphatic (straight) compound with six chlorine atoms, mainly created as a by-product in the manufacture of other chlorinated aliphatic compounds.



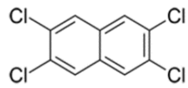
Decabromodiphenyl ether, decaBDE (commercial mixture, c-decaBDE) is the fifth of the polybrominated diphenyl ethers (PBDEs) to be covered by the convention. DecaBDE is composed of two ring structures with 10 bromine atoms, i.e. the substance is fully brominated and only one congener exists (BDE#209). The commercial mixture c-decaBDE consists of approximately 99% decaBDE with trace levels of other PBDEs.



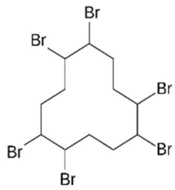
Short-chain chlorinated paraffins (SCCPs) are complex mixtures of certain organic compounds containing chloride: polychlorinated n-alkanes. The chlorination degree of CPs can vary between 30 and 70 wt %. Commercial products contain complex mixtures of isomers and congeners because the chlorination reaction method used for their production has low positional selectivity. The carbon chain length of commercial SCCPs are usually between 10 and 30 carbon atoms (C10 - 13). Two other groups of chlorinated paraffins with longer chain lengths, the medium-chain paraffins (C14-17) and the long-chain paraffins (C18 and more), are not considered POPs and not included under the Stockholm Conventions.



Pentachlorophenol (PCP) and its salts and esters. PCP consists of a ring structure with five chlorine atoms and an OH group. The main derivative of PCP used has been the sodium salt of PCP (Na-PCP), which dissolves easily in water. Other derivatives such as the potassium salt, K-PCP, and the lauric acid ester, L-PCP, are of minor importance (IPCS, 1987).



Polychlorinated naphthalenes (PCNs) consist of two cyclic structures with varying numbers of chlorine atoms in varying locations, as do PCDD, PCDF and PCB. Commercial PCNs were mixtures of up to 75 chlorinated naphthalene congeners plus by-products and are often described by total fraction of chlorine (one of the congeners shown to the right).



Hexabromocyclododecane (HBCDD or HBCD) is a cycloaliphatic (i.e. not a double ring structure as are most of the other POPs) compound with six bromine atoms. The bromine atoms can have different configurations, and commercial HBCDD is made up of three so-called "chiral diastereomers", each with their own chemical identification numbers (CAS numbers). The three diastereomers, α-, β- and γ-HBCDD, are all chiral (i.e. not mirror images and as such, not superimposable) and exist as pairs of enantiomers in technical HBCDD. After release to the environment, the enantiomers may interact differentially with other chiral molecules in biological systems, complicating risk assessments of HBCDD. The total sum of og α-, β- and γ-HBCDD is designated *Σ*-HBCDD and is used e.g. in food monitoring or environmental monitoring (or *ΣHBCD).*

1.3.2 POPs covered by the Convention and included in the previous NIPs

Polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF) are two groups of cyclic organochlorine compounds. The presence of chlorinated cyclic structures generally forms relatively stable, and, consequently, persistent compounds. In Denmark the designations "dioxin" or "dioxins" are jointly used for the two substance groups, and for readability, such designations are also used in this implementation plan.

Dioxins have never been intentionally produced in Denmark but are formed unintentionally through a series of industrial chemical processes and incineration processes.

Each substance group consists of a number of substances, or "congeners", which are characterised by the number of chlorine atoms and the location of chlorine atoms inside the molecule. The different congeners have different levels of toxicity, and to obtain an overall measure for the total effect of dioxin content in a sample, various systems to calculate the dioxin toxicity equivalents (TEQ) have been developed at the international level. In this report, values are stated using units from two systems stated as I-TEQ and WHO-TEQ, respectively. The first system is often used for release inventories, whereas the WHO system is used for food and animal feed sample analysis, for example. The WHO system also has toxicity equivalency factors (TEF) for a number of “dioxin-like” (or coplanar) PCBs.

Polychlorinated biphenyls (PCB) are a group of chlorinated organic compounds, which, like dioxins, are structured around two cyclic structures. A subgroup of the PCBs is the “dioxin-like PCBs”, similar in toxicity to dioxins.

PCB was previously produced for various technical purposes and is also formed unintentionally in the same way as dioxins. In the Statutory Order on PCB/PCT, PCB is regulated along with another substance group called polychlorinated terphenyls (PCT, with three ring structures). However, historically, compared with the use of PCB, the use of PCT has been much less significant, and PCT is not covered by the Stockholm Convention.

Hexachlorobenzene (HCB) comprises one single cyclic structure with six chlorine atoms. HCB was previously widely used as a pesticide and chemical intermediate in production of other chemical substances, and HCB is still produced for these purposes in some countries. HCB is also unintentionally formed in thermal and certain chemical processes.

Pentachlorobenzene (PeCB) is composed of a single cyclic structure with five chlorine atoms and therefore it resembles HCB. Pentachlorobenzene has previously had widespread use as a pesticide and as a chemical intermediate product, and the substance is still produced for these purposes in some countries. Pentachlorobenzene is also formed unintentionally in the same way as HCB in incineration processes and in some chemical processes.

DDT is a chlorinated organic pesticide commonly used in tropical areas, particularly as a means to combat malaria-transmitting mosquitoes. Due to a lack of good alternatives to some uses of DDT, the substance has a special status compared with the other POP pesticides in the Stockholm Convention, as there are no elimination requirements for uses, merely restrictive requirements.

PFOS is a substance group which includes perfluorooctane sulfonic acid, its salts, and perfluorooctanesulfonic fluoride (here collectively designated as “PFOS”). These substances are all built up in a chain with eight carbon atoms fully fluorinated (i.e. perfluorinated) which give the substances their stability. There is a sulphur atom at the end of the chain which can link to various chemical groups. The gross formula of the substances covered by the POP Regulation is $C_8F_{17}SO_2X$, where X may be hydroxide, a metal salt, halogenide, amide, or other derivatives, including polymers. The Stockholm Convention does not state this gross formula, but rather provides examples of the group with a number of specific substances. The Convention uses the abbreviation PFOS specifically for perfluorooctane sulfonic acid, whereas in the POP Regulation and in many other contexts, PFOS is used as an abbreviation for the whole group of PFOS substances. In this implementation plan, the term PFOS is used in the same way as the term is used in the POP Regulation, i.e. for the whole group of substances.

The PFOS substances make up a smaller part of a large group of per- and polyfluoroalkyl substances (PFAS) and studies in Denmark have typically included PFOS and a number of other PFAS. Two other PFAS are under evaluation for inclusion under the Stockholm Convention: perfluorohexane sulfonic acid (PFHxS) and perfluorooctanoic acid (PFOA), which are further mentioned below.

Hexabromobiphenyl (hexaBB) has been used as a flame retardant in plastic in electronic equipment and is in the group of polybrominated biphenyls (PBB). The substances are built up in the same way as PCB, but with bromine atoms instead of chlorine. Several types of PBB have been used, but only hexaBB is covered by the Convention. HexaBB has been used as a flame retardant in plastic, primarily in the 1970s. The technical compound which contained hexaBB was banned in North America and in the EU in 1973. All PBBs are covered by the RoHS Directive and have been restricted in electrical and electronic equipment since 2006.

Tetra- and pentabromodiphenyl ether make up the most important components of a technical mixture known as pentabromodiphenyl ether (commercial pentaBDE or C-pentaBDE). Technical pentaBDE has been used primarily as a flame retardant in polyurethane foam, used in mattresses, upholstery and in vehicles. Commercial pentaBDE typically contained around 60% pentaBDE, 24-38% tetraBDE and 4-8% hexaBDE.

Hexa- and heptabromodiphenyl ether make up important parts of the technical mixture octabromodiphenyl ether (commercial octaBDE or c-octaBDE), which has been used primarily as a flame retardant in ABS plastics in electronic equipment. Technical octaBDE typically contained around 10% hexaBDE and around 40% heptaBDE.

The other old substances in Annex A are all pesticides that have not been used in Denmark for many years.

1.3.3 Other POPs covered by the POP Protocol or under consideration for uptake under the Stockholm Convention

In addition to the 28 substances covered by the Stockholm Convention, the POP Protocol covers one more substance group: polyaromatic hydrocarbons (PAH).

A party can submit a proposal to the Secretariat of the Stockholm Convention to include new chemical substances in Annexes A, B and/or C. The proposal must include information about the persistence of the substance, bioaccumulation, potential for transport over long distances in the environment, and harmful effects. If the Secretariat finds that the proposal includes the information stated, the proposal is forwarded to the Persistent Organic Pollutants Review Committee under the Stockholm Convention, which first examines the proposal using screening criteria stated in the Convention. If it is then decided to go further, a risk profile and a risk management evaluation is prepared before the Conference of the Parties decides whether the chemical substance can be included in one or more of the annexes.

The following substances are currently under review by the Persistent Organic Pollutants Review Committee in order to determine whether they are to be included in the list of substances under the Convention:

Dicofol is a pesticide that has not been used in Denmark for many years, if ever.

Perfluorooctanoic acid (PFOA), its salts and PFOA-related compounds. PFOA has a similar structure as PFOS, but without the sulphur atom. Belongs to the class of PFAS. PFOA has traditionally been used widely in the production of fluoropolymers, for the production of non–stick kitchenware and other food processing equipment (e.g. the brand name Teflon®). PFOA-related compounds, including side-chain fluorinated polymers, are or have been used as surfactants and surface treatment agents in textiles, paper and paints, as well as firefighting foams. Commercial products often consist of a mixture of varying chain lengths, and PFOA may be present at low levels in mixtures primarily consisting of homologues with shorter chain length.

Perfluorohexane sulfonic acid (PFHxS), its salts and PFHxS-related compounds. PFHxS has a similar structure as PFOS, but with a chain of six perfluorinated C-atoms instead of eight. It belongs to the class of PFAS and has to some extent been used as substitute for PFOS. Commercial products often consist of a mixture of varying chain lengths and PFHxS may be present at low levels in mixtures primarily consisting of homologues with other chain lengths.

2. Country baseline

2.1 Country profile

2.1.1 Geography and population

Denmark covers an area of 43,094 km² and consists of the peninsula Jutland (29,776 km²) and 406 islands. Zealand, where the capital, Copenhagen, is located, is the largest of the islands (7,031 km²). Denmark has almost 5.8 million inhabitants per 1 January 2018, corresponding to about 1.1% of the total EU population. The average population density is about 123 per km². Denmark has a temperate coastal climate.

2.1.2 Political and economic profile

Denmark's form of governance is parliamentary democracy with a royal head of state. The Danish Parliament (the *Folketing*) has the exclusive right to adopt legislation. The Folketing has 179 members, elected through proportional representation. One hundred seventy-five of the members are elected in Denmark, while Greenland and the Faeroe Islands each elect two members. Denmark has been a member of the EU since 1973 but has opted out of the cooperation within four areas: The Monetary Union, the Common Security and Defense Policy, the Justice and Home Affairs and the Citizenship of the European Union.

In 2017, Denmark's gross domestic product (GDP) in constant prices was DKK 2,150 billion, corresponding to a GDP per inhabitant of DKK 371,700. The GDP per inhabitant was approximately 67% above the EU28 average in 2016, while the overall price level for goods and services was 39% over the EU28 average.

2.1.3 The overall environmental situation in Denmark

The Danish approach to regulating use and releases of chemical substances is influenced by the following characteristic features of the situation in Denmark:

- Denmark has a high population density and a high level of economic activity. Globally, Denmark has one of the highest levels of consumption of goods, resources and energy per inhabitant. Because of the high level of consumption of consumer goods produced worldwide, the population could potentially be exposed to a large number of chemicals.

- Forests and natural areas represent less than 15% of the terrestrial area; Denmark is a country with numerous islands surrounded by vulnerable shallow-water marine areas. Therefore, the environment's capacity for absorbing pollutants is relatively small.

- Whereas problems linked to discharges of hazardous substances from large point sources have generally been solved, focus has shifted to the environmental problems linked to modern lifestyle, domestic wood stoves and industrialised agriculture.

2.1.4 Central approaches and procedures

Key approaches and procedures to ensure enforcement of relevant legislation on POPs are, as described in the previous action plan, the following:

- a system for approval of pesticides,
- a system for environmental permits for companies subject to authorisation,
- a system for registration of marketed mixtures (chemical products) and their constituents,
- a registration and approval system for waste treatment enterprises,

- a registration system to monitor waste from enterprises and municipalities from "door to grave".

In addition, a comprehensive system has been developed and implemented under the EU's chemical framework legislation, REACH, which requires and ensures generation of data for use in registration, assessment and authorisation of chemical substances.

2.2 Environmental policy, statutory and institutional frameworks

2.2.1 Environmental policy, strategy for sustainable development and statutory frameworks

Denmark's environmental policy builds on a general principle that Danish society should promote economic progress while concurrently allowing room for social development and environmental improvement. The objective is for Denmark to develop in a sustainable direction, e.g. by ensuring better integration between the environment and other sectors in society, improving resource efficiency, and increasing awareness and responsibility among businesses and consumers' accountability.

The first national strategy for sustainable development was published in 2002 as part of the Danish contribution to the world summit in Johannesburg. The most recent strategy for sustainable development, *"Udvikling i balance" ("Balanced development"),* was published in 2014. The Danish Government's strategy for sustainable development lays down "green" goals under the overall heading "A clean environment, a rich nature and a good climate" and also states seven specific "green" sustainability targets for Denmark:

- Greenhouse gas emissions reduced by 40% in 2020 compared to 1990.
- Electricity and heat supply based fully on renewable energy sources by 2035 and Denmark's total energy supply, including the transportation sector, based on such sources by 2050.
- Recycling of domestic waste increased to 50% by 2022.
- Reduction in the environmental and human health load from the use of pesticides by 40% by the end of 2015 compared to 2011.
- Clean air and regulation of problematic chemicals – Denmark must meet international agreements and goals.
- Denmark must maintain its diverse nature and protect the habitats of animals and plants in open land and in forests. In the longer term, favourable conservation status of species and natural habitats must be secured.
- Fjords, coastal waters, lakes, watercourses and groundwater must meet the requirements of the Water Framework Directive and the Marine Strategy Framework Directive.

With regard to chemicals, in line with EU's 7th Environment Action Programme, the overall goal is that within one generation (2020), chemicals will only be produced and used in ways that do not lead to significant negative impacts on health and the environment. This goal is underpinned by the objective that substances posing a danger to the environment and health must be banned, restricted or replaced. The Danish efforts within the field of chemical regulation and management should also be seen as supportive, where applicable, to fulfilment of UN's 2030 Agenda as expressed in the 17 Sustainability Development Goals (SDGs) and their associated targets.

The strategy for sustainable development is supplemented by a number of more specific environmental policy strategies, e.g. the Joint Chemicals Initiative, the Waste and Resource Strategy ("Denmark without waste – Strategy & Resource Plan 2013-2018"), and the PCB Action Plan.

New Joint Chemicals Initiative. In November 2017, the Danish Government and all the parties in the Danish Parliament adopted a new action plan on chemicals called the "*New Joint Chemicals Initiative 2018-21*" as the successor of a similar initiative from 2013-2017 and a number of earlier Chemical Action Plans. The agreement on the Joint Chemicals Initiative is based on "the long-term vision in the EU's 7th Environment Action Programme for a non-toxic environment in which citizens are protected against environmental impacts and risks to their health and well-being, and this requires special initiatives in relation to chemicals in products and food". The new initiative has five cornerstones:

- Informed consumers
- Fair opportunities for enterprises
- The five adverse effects in focus
- Research and knowledge-building
- EU strategy.

The two cornerstones that most directly relate to existing as well as potentially new POP-chemicals under the Stockholm Convention are the "five adverse effects in focus" and "EU Strategy" cornerstones. The Danish strategy on "five adverse effects in focus" will target the most harmful chemical substances in consumer products, biocidal products, food and food contact materials, and will focus in particular on influencing EU policy and legislation. Consumers should be protected against substances that:

- are carcinogenic, mutagenic or toxic for reproduction (CMR substances)
- affect brain development
- are endocrine disrupting
- are allergenic, or
- are of high concern to the environment (PBT/vPvB substances).

This focus is also reflected in having EU strategy as one of the cornerstones of the joint Chemicals Initiative, where the overall aim is to *"encourage and contribute to progress in the EU with a view to strong chemicals regulation that ban the worst chemical substances"*. It is important to Denmark that regulatory initiatives in the EU are based on solid scientific documentation and on alliances and collaboration with other countries with the same approach to regulation of hazardous chemicals.

The Joint Chemicals Initiative agreement lists a number of specific target areas and actions within each of the five cornerstones. The total budget of the initiative from 2018-2021 is approximately 285 million DKK (approximately 38 million Euro).

Waste Strategy. The current Danish strategy on waste, "Denmark without waste", dates from 2013 and is the latest in a series of national strategies on waste. The strategy covers the period 2013-2018. The vision of the strategy for Denmark has been to conserve to a larger extent the resources and materials in the waste we produce, and to increase recycling and reduce incineration of our domestic waste. Thus, the two overall focus areas of the strategy are:

- We shall incinerate less of our waste and improve our ability to exploit its values and resources.
- We shall reduce the environmental load from waste to ensure that economic growth does not lead to an equal increase in impacts on nature and the environment.

Specific focus areas of the strategy are: more recycling of materials in waste from households and the service sector, more recycling of materials in electronic waste and shredder waste, replacement of waste incineration by biogasification and recycling, better exploitation of important plant nutrients in the waste such as phosphorus, increase in the quality of waste recycling within the building and construction sectors, and investigation and exploitation of the possibilities of "green transition" for private enterprises. The Waste Strategy is made more specific and operationalised in the supporting Resource Plan for Waste Management (2014) as well as in a strategy for the prevention of waste, "Denmark without Waste II" (2015). The latter comprises two cross-cutting themes, "Green transition in Danish enterprises" and "Green consumption", and five specific target areas for action: less wasting of food, building and construction, clothes and textiles, electronics, and packaging. The target areas "building and construction" and "electronics" are those having the most direct relevance to management of POPs.

In July 2015, the relevant industry and professional organisations and associations were informed directly by the Danish Environmental Protection Agency about the entering into force of common limit values for ten new POP substances in waste, and the implications for handling and management of waste containing these substances.

Interministerial working group on PCB in Buildings. In 2011 the Danish Government published the "Action Plan on Managing PCB in Buildings – Indoor Environment, Working Environment and Waste". The Action Plan contained 19 initiatives and was coordinated by an interministerial working group. The initiatives are described in section 2.3.8. The working group is no longer active.

2.2.2 Roles and responsibilities of national authorities

The roles and responsibilities of national authorities, which, in various ways, are involved in activities linked to carrying out the implementation plan are outlined below.

The Danish Ministry of Environment and Food is responsible for the overall development and revision of national Statutory Orders, national environmental laws, EU Regulations and directives as well as international agreements and Conventions. The Danish Ministry of Environment and Food participates on behalf of Denmark in the Conference of the Parties (COPs) under Stockholm Convention and negotiates technical as well as political issues related to the EU POP regulation. The Ministry is as well responsible for the reporting under the Stockholm Convention.

The Danish Environmental Protection Agency (Danish EPA) under the Danish Ministry of Environment and Food administrates a substantial number of acts, statutory orders and European Union acts, which relate to environmental protection, chemical substances and mixtures (chemical products), waste management and contaminated soil, all of which are areas where POPs occur together with many other substances of concern. The Danish EPA approves pesticides before they are placed on the Danish market and is also responsible for approval of imports and exports of waste, including waste containing POPs. Finally, the Danish EPA performs supervisory and control functions through its Chemical Inspection Service.

The Danish EPA collects knowledge and data about environmental impacts and monitors trends in the environmental situation. The Danish EPA initiates studies and research projects within the environmental area, participates in international environmental cooperation and manages environmental studies in the Arctic. The Agency develops and operates a significant number of environmental databases. New knowledge is communicated in guidelines and publications, through a comprehensive website presenting relevant and topical EPA information, as well as through active press and media work. The website of the Danish EPA includes comprehensive information about POPs for use by citizens, enterprises and other authorities.

Further, the Danish EPA is also responsible for the National Monitoring Programme for the Aquatic Environment and Nature, NOVANA. The programme aims at generating knowledge about environmental conditions in Denmark. This knowledge constitutes part of the basis for managing Danish nature and environment policy, and it forms part of the decision-making basis for environmental policy initiatives. Data from the programme are also included in the documentation of effects of administrative initiatives for nature and the environment. Additionally, Denmark uses this knowledge when reporting on EU directives and international conventions. The current programme covers the period from 2017-2021 and includes monitoring of a number of POPs as described in section 2.3.14.

The Danish Working Environment Authority under the Danish Ministry of Employment is the national authority responsible for administering the Danish Act on the Working Environment. In relation to POP-substances, the Authority checks that PCB and other POPs are managed appropriately in the working environment. In collaboration with the Danish EPA, the Danish Working Environment Authority manages the Product Register, which lists the dangerous chemicals used professionally in Denmark. The Danish Working Environment Authority and the Danish EPA use information from the Product Register as the basis for prioritisation of their initiatives and to regulate, perform checks, make risk assessments, monitor and prepare statistics. The Danish Working Environment Authority is responsible for the parts of the Danish Government's PCB Action Plan that concern the working environment.

The Danish Health Authority under the Ministry of Health is the national agency given the task of promoting public health and ensuring a good framework for the health service in Denmark. The Authority collaborates with the Danish EPA and a number of other institutions on analyses and carrying out initiatives on the impacts of POPs to human health. The Danish Health Authority provides guidance on POPs and health, including PCB in the indoor climate, and also participates in implementing the Danish Government's PCB Action Plan. The Danish Health Authority's **Advisory Scientific Committee on Environmental Health** disseminates research results and communicates broadly on issues related to environment and health, including POPs.

The Danish Veterinary and Food Administration under the Ministry of Environment and Food is responsible for monitoring and inspection of POPs in food and animal feed and migration of POPs from food contact materials. The Danish Veterinary and Food Administration also negotiates limit values etc. for POPs in food and migration of POPs from food contact materials to food in the EU.

The Danish Building and Property Agency under the Danish Ministry of Transport, Building and Housing is responsible for studies and management of PCB in buildings owned by the state.

2.2.3 Role of municipal authorities

The municipalities are responsible for assigning how and where waste (except for recyclable commercial waste) generated in the municipality should be disposed of, including waste containing POPs. For recyclable commercial waste, enterprises can choose between approved recycling plants, and can also transfer responsibility for treatment of recyclable waste to an approved waste collector. Against payment, private enterprises may use municipal recycling sites. The local councils must offer either assignment or collection schemes for household waste and for commercial waste to be recycled, incinerated and/or landfilled. Moreover, municipalities are required to draw up waste plans and regulations on the scope and organisation of waste schemes. Municipalities also supervise and classify waste in the municipality.

2.2.4 International commitments in relation to POPs

Along with the other Nordic countries, for many years Denmark has been at the forefront of promoting safe chemicals management globally. Among other areas, chemicals management is carried out on the basis of research in the Arctic showing that chemical substances end up far from where they were produced and used (see information on ongoing activities in section 2.3.14).

Pursuant to the new joint chemicals initiatives 2018-21, Denmark aims to remain a visible player regarding strengthening regulation globally. The joint chemicals initiatives are about globally improving and standardising regulations on chemicals, as well as ensuring safe development and use of chemicals that are not hazardous to health. Effective implementation and further development of the existing agreements are necessary, in addition to making amendments or new agreements within new areas posing risk to the environment or health.

In addition to the work carried out in connection with the Stockholm Convention, Denmark participates actively in further developing a number of related international and regional conventions on chemicals and waste, such as:

- UNECE's POP Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution on Persistent Organic Pollutants.
- Rotterdam Convention on the Prior Informed Consent (PIC) Procedure for Certain Hazardous Chemicals and Pesticides in International Trade.
- The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal.
- Helsinki Convention on the Protection of the Marine Environment of the Baltic Sea Area (Pursuant to the Convention, the parties are required to ban final use of DDT and derived DDE substances as well as the use of PCB and PCT except for special purposes).
- The OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic, the objective of which is to reduce emission of substances that are toxic, persistent and liable to bioaccumulate in the marine environment to a level where such substances are not harmful to humans and nature and aimed at completely eliminating such substances).

Furthermore, pursuant to the new joint chemicals initiatives 2018-21, in the period from 2018-2021 Denmark will actively prioritise participation in the development of recommendations for a SAICM (Strategic Approach to International Chemicals Management) Beyond 2020 regime for sustainable chemicals and waste management globally. In 2018-19, Denmark will also work to support the implementation of SAICM in order to reach the 2020 goal.

Under the auspices of the Nordic Council of Ministers, Denmark cooperates with the other Nordic countries on issues related to POPs. The cooperation of the Nordic Ministers for the Environment is based on six-year environmental action programmes. The Nordic Environmental Action Programme of 2013-2018 contains two priorities in relation to POPs in particular:

- Preventing and reducing transboundary emissions of hazardous substances such as mercury and persistent organic pollutants (POPs) in cooperation with the Arctic Council.
- Identifying new chemicals proven hazardous to human health and the environment through systematic screening programmes, including northern areas and the Arctic.

Finally, under the auspices of the Arctic Council, Denmark is working actively to protect the Arctic ecosystem, to preserve, reinforce and restore environmental quality and the sustainable exploitation of natural resources in the Arctic, to monitor conditions in the Arctic environment as well as to identify, reduce and, as a final goal, eliminate pollution. The Arctic Contaminants Action Program (ACAP) acts as a strengthening and supporting mechanism to encourage national actions to reduce emissions and other releases of pollutants, whereas the Arctic Monitoring and Assessment Programme (AMAP) monitors the Arctic environment, ecosystems and human populations, and provides scientific advice to support governments as they tackle pollution and adverse effects of climate change.

2.2.5 Legislation on POPs

2.2.5.1 Close interaction between European Union legislation and national law

Regulation of POPs and waste containing POPs in Denmark is characterised by close interaction between EU legislation and national law. The Stockholm Convention is implemented in Denmark via the POPs Regulation.

The Stockholm Convention is primarily implemented by Regulation (EC) no. 850/2004 on persistent organic pollutants (the POP Regulation) with subsequent amendments and supplements in response to new substances listed under the Convention. The Regulation was amended most recently by Commission Regulation (EU) no. 2016/460 of 30 March 2016 amending Annexes IV and V.

According to Article 288 of the Treaty on the Functioning of the European Union, a Regulation is directly applicable in all Member States. The POP Regulation is based on article 192 (former Art 175) of the Treaty. According to Art 193 the Regulation represents the minimum requirement, allowing Member States to introduce or continue employing more stringent environmental regulation. The POP Regulation restricts marketing and sets conditions for production, use and waste management of POPs which are covered by bans or restrictions pursuant to the Stockholm Convention and/or UNECE's POP Protocol. This applies to the substances on their own and to the POPs in mixtures and articles. The POP Regulation is a testament to the ambition of moving further than prescribed by international obligations, for example in relation to chemical substances and waste management. Restrictions on marketing, production and use are included in Annexes I and II. Annex III includes the list of substances subject to release reduction provisions from unintentional formation of POPs. Requirements for waste management are laid down in Annexes IV and V.

The POP regulation is currently being revised as a new recast Regulation has been proposed (COM(2018) 144 final 2018/0070 (COD)[6]. The revision of the POP Regulation is based on:

- The latest amendments to the Annexes of the Stockholm Convention;
- A greater involvement of the European Chemicals Agency (ECHA) in certain administrative, technical and scientific tasks necessary for the implementation of the Regulation. The proposal includes a role for the Agency in receiving, monitoring and exchanging information submitted to it under the provisions of the proposal. This includes providing advice and risk assessments on substances likely to be proposed for listing in the annexes to the Stockholm Convention or the Arhus Protocol. As the Agency currently manages other information activities in the framework of EU chemicals legislation, including REACH, CLP and the PIC Regulation, it is considered appropriate to specify a similar role for the Agency in order to enhance consistency in regulatory implementation;
- A wish to support the enforcement of the POPs Regulation by Member States by including a coordination role for the Forum for Exchange of Information on Enforcement established by REACH;
- Changes in the legal mandate of the Committee under the POP Regulation;
- Technical amendments to the operative provisions, such as clarifying existing definitions and including new definitions of manufacturing, use and a closed-system site-limited intermediate;
- Streamlining reporting requirements in light of the conclusions reached in the recently adopted Report on Actions to Streamline Environmental Reporting;

[6] See also https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2018:0144:FIN

- Simplifications in reporting and monitoring processes with a focus on automation, lower frequency and relevance of data, in line with the Union's Better Regulation agenda and the findings of the Fitness Check on Environmental Reporting and Monitoring;
- Adjusting the POP Regulation in line with the Commission's Digital Single Market strategy with provisions to improve citizens' access to information and transparency.

The final version of the recast POP Regulation was not yet presented at the time of the finalisation of this report. Therefore, the changes and implications following the final version and subsequent implementation in Denmark will be addressed in the next NIP.

The POP Regulation is supplemented by a number of EU regulations and directives which, along with the POP Regulation, implement all the provisions of the Convention. The following section describes applicable Danish legislation on POPs and waste containing POPs, including marketing and bans and approval schemes, evaluation of existing chemicals for POP properties, as well as requirements for supervising and controlling compliance with the law. Legislation is described under the following subheadings which reflect Denmark's commitments under the Stockholm Convention:

- Restriction on the newly added POPs;
- Restriction on production, use and marketing of Annexes A and B pesticides;
- Restriction on intentional production, use and marketing of PCB;
- Restriction on production, use and marketing of PFOS;
- Restriction on production, marketing and use of the substances hexabromobiphenyl and tetra-, penta-, hexa- and hepta-bromodiphenyl ether;
- Release reduction of unintentionally formed POPs;
- Releases from stocks;
- Management of waste containing POPs.

The country baseline in relation to legislation on POPs is concluded with a description of legislation concerning POPs in food and animal feed, which is one of the areas where Union legislation (and thus Danish legislation) is more specific than the Stockholm Convention.

The POP Regulation also includes general commitments built on the provisions of the Convention, including listing new chemical substances in Annexes A, B and C, exchange of information to the public, research, etc. These are not further described in this section (refer to the relevant sections in Chapter 3 under the POPs situation in Denmark and sections in Chapter 4 concerning planned initiatives).

The Danish Chemical Substances and Products Act 115 of 26 January 2017 [Da: Kamikalieloven] provides the main legal mandate for the regulation of chemicals in Denmark. The Act, along with the Danish Statutory Order on POPs and specific individual statutory orders (mentioned below), comprise the relevant bans and restrictions in the POP Regulation, REACH Regulation and the Plant Protection Products Regulation. The Danish legislation along with the EU Regulations set the legal framework for POPs in Denmark, as EU regulations themselves are directly applicable in Denmark.

The Danish EPA Chemical Inspection Service supervises compliance with the legislation and ensures that illegal situations are legitimised. This may mean that illegal mixtures and articles must be withdrawn from the Danish market or legitimised in other ways. Violations of the regulations are liable to a fine, or in more serious cases, to imprisonment for up to two years.

2.2.5.2 Restrictions on the newly added POPs

The restrictions on the newly added substances governed by the EU regulations are, as mentioned above, directly applicable in Denmark. Danish actuating legislation is included in the description where relevant. A list of the EU and Danish legislation on the newly added POPs are provided in TABLE 3. In order to provide an overview, the table also includes the current exemptions.

TABLE 3. List of the EU and Danish legislation on the newly added POPs

Substance	Instruments	Specific exemptions*	Limit value in waste**	Supplemental Danish legislation
Hexachlorobutadiene (HCBD)	POP Regulation Annex I; Part B; Commission Regulation no. (EU) 2012/519.	None	100 mg/kg (Annex IV) and 1,000 mg/kg (Annex V). Commission Regulation (EU) no. 2014/1342	No
Short-chain chlorinated paraffins (SCCPs)	POP Regulation Annex I; Part B; Commission Regulation (EU) no. 2015/2030	Substances or preparations containing SCCPs in concentrations lower than 1 % by weight or articles containing SCCPs in concentrations lower than 0.15 % by weight. Articles already in use before or on 10 July 2012.	10,000 mg/kg in both Annex IV and V Commission Regulation (EU) no. 2015/2030	No
Pentachlorophenol (PCP)	REACH Annex XVII (Entry 22), Commission Regulation (EU) 2009/552	Substances, or in mixtures, in a concentration equal to or greater than 0.1 % by weight.	PCP waste stream: Landfilling is prohibited (Waste Acceptance Decision 2000/53/EC) Commission working on setting limit value[7]	Statutory Order 854 of 05/09/2009 on PCP bans/restricts in concentrations on 5 ppm (mg/kg) or beyond

[7] See https://circabc.europa.eu/webdav/CircaBC/env/pop/Library/01-meetings_authorities/15%20-%2015th%20Competent%20Authorities%20meeting%20on%20POPs%20-%206%20December%202016/02%20-%20Documents/POP-CA_12-16_20-Annex%201-PCP%20limit%20values.pdf

Substance	Instruments	Specific exemptions*	Limit value in waste**	Supplemental Danish legislation
Hexabromocyclododecane (HBCDD)	POP Regulation Annex I, Part A by Commission Regulation (EU) 2016/293	For unintentional trace contaminants, concentrations are allowed equal to or below 100 mg/kg (0.01 % by weight) (up for review by the Commission by 2019). 1. Use, production and placing on the market based on authorisation (Title VII of Regulation (EC) No 1907/2006 until 26 November 2019. 2. Articles that contain hexabromocyclododecane as a constituent of such articles and are already in use before or on 22 March 2016. 3. The placing on the market and use in buildings of imported expanded polystyrene articles that contain HBCDD is allowed until 26 November 2019. Such articles already in use by that date may continue to be used. 4. Use must be identifiable by labelling or other means throughout its life cycle.	Commission Regulation (EU) 2016/460, Annex IV and V part 2. Limit value set at 1,000 mg/kg in both Annex IV and V (up for review by the Commission by 2019).	No
Polychlorinated naphthalenes (PCNs)	The POP Regulation in Annex I, Part B by Commission Regulation (EU) No 519/2012.	Use is restricted to the placing on the market and use of articles already in use before or on 10 July 2012 containing PCNs as a constituent of such articles	**Commission regulation** (EU) No 1342/2014, Annex IV and V, Part 2, as revised by Commission Regulation (EU) 2016/460 for Annex V, Part 2. Limit value set at 10 mg/kg (Annex IV) and 1,000 mg/kg (Annex V).	No

Substance	Instruments	Specific exemptions*	Limit value in waste**	Supplemental Danish legislation
Decabromobiphenyl (deca-BDE)	REACH Annex XVII (Entry 67), Commission Regulation (EU) 2017/227	Ban from 2 March 2019. However, concentrations will still be allowed equal to or greater than 0.1 % by weight. Exemptions are: a) Articles placed on the market before 2 March 2019; b) Electrical and electronic equipment within the scope of RoHS Directive 2011/65/EU; *Note: RoHS itself sets limit value to 0.1 % by weight (Annex II)* c) in the production of aircraft produced before 2 March 2027; d) For production before 2 March 2019 of motor vehicles (within the scope of Directive 2007/46/EC), agricultural and forestry vehicles (within the scope of Regulation (EU) No 167/2013) or machinery (within the scope of Directive 2006/42/EC). e) Spare parts for the products mentioned in c and d.	No limit values set	No

* Exemptions which are outdated are not included in this table. The table provides an overview. For the detailed requirements involved, please refer to the EU legislation mentioned.

** Conditions for applying the limit value in Annex V, Part II are described below under *Management of waste containing POPs.*

2.2.5.3 Restrictions on POPs pesticides

TABLE 4 includes a list of regulations pertinent to the pesticides listed in Annexes A and B of the Stockholm Convention.

The POP Regulation bans production, marketing and use of the 15 POP pesticides covered by bans under the Convention, and DDT, which is restricted under the Convention alone. All pesticides in the POP Regulation are on the list of banned substances without specific exemptions (except for pentachlorophenol which has non-pesticidal applications).

TABLE 4. List of the EU and Danish legislation on pesticides listed in Annexes A and B of the Stockholm Convention

Chemicals legislation relevant for intentional use of POP pesticides	Provisions relevant for POPs
The POP Regulation Regulation (EC) no. 850/2004	Ban on production, marketing and use of aldrin, chlordane, chlordecone, dieldrin, DDT, endrin, heptachlor, mirex, toxaphene, α -HCH, β-HCH, lindane (γ-HCH), hexachlorobenzene, hexachlorobutadiene, pentachlorobenzene
The PIC Regulation Regulation (EU) no. 649/2012	Ban on exports of all Annexes A and B substances
The REACH Regulation (EC) no. 1907/2006.	The criteria for identification of persistent, bioaccumulative and toxic substances (vBvP/PBT substances) and assessment of the (v)P, (v)B and T properties of a substance, Annex XIII. One of the substances, PCP, is not included in the Annexes to the POP Regulation but listed in Annex XVII to REACH and thereby restricted.
Plant Protection Regulation (EC) no. 1107/2009	An active substance, a safener (substances that increase safety when using the pesticide) or synergists may only be approved if the substance is not considered a persistent organic pollutant (POP).
The Danish Chemical Substances and Products Act - Act no. 115 of 26 January 2017 The Statutory Order on POPs Statutory Order no. 820 of 29 September 2003	Statutory Order no. 820: Prohibition provision on old banned POPs. Act 115: General legal mandate for chemical management, including the POP substances.

The banning provision of the POP Regulation is supplemented by the Regulation on Marketing Plant Protection Products which stipulates that an active substance, a safener (substances that increase safety in use of the pesticide) or synergists may only be approved if the substance is not considered a persistent organic pollutant (POP).

Furthermore, the REACH Regulation and the Regulation on Marketing Plant Protection Products include provisions which help prevent production and use of substances with POP properties. The REACH Regulation includes the possibility for introduction of new restrictions for production, use or marketing of substances as such, in mixtures or in products, by listing them in Annex XVII to the Regulation or admitting substances to Annex XIV, substances requiring approval.

2.2.5.4 Restriction on other Annex A and B substances addressed in the NIP 2012

TABLE 5 includes a list of restrictions on other Annex A and B substances addressed in NIP 2012.

The requirements of the POP Regulation are supplemented by the Danish Statutory Order on PCB/PCT no 47 of 12/01/2016, implementing the PCB/PCT Directive 96/59 to which the POP Regulation refers. Use of large transformers and capacitors containing PCB (weight >1 kg or an effect of > 2 kVar) were banned on 1 January 1995. Small transformers and capacitors (weight up to 1 kg or output of up to 2 kVar) containing PCB may (still) be used until the end of their operational life. Statutory Order no. 925 of 13 December 1998 implemented regulations stipulating that large transformers and capacitors (weight >1 kg or an effect of >1 kVar) were to be discontinued by no later than 1 January 2000. In some respects the current Danish legislation on PCB is stricter than in the Directive: a) The Statutory Order on PCB/PCT includes stricter provisions than in the Stockholm Convention and the PCB/PCT Directive as regards the date for decontamination and/or disposal of equipment containing PCB. The Statutory Order requires that large types of equipment must be decontaminated and/or disposed of as soon as possible and no later than 1 January 2000. b) The Statutory Order on PCB/PCT is also stricter than the PCB/PCT Directive in relation to disclosure requirements as well as the ban on PCB refills.

TABLE 5. List of the EU and Danish legislation on other Annex A and B substances addressed in the NIP 2012

Substance – Ban on production, marketing and use	Instruments	Current specific exemptions*	Limit value in waste**	Supplemental Danish legislation
Hexabromobiphenyl	POP Regulation, Annex A as amended by Commission Regulation (EU) No 757/2010. (included in original POP Regulation, Annex A, Part B).	None	Commission Regulation (EU) 1195/2006 and Commission regulation (EU) 172/2007 Annex IV: 50 mg/kg Annex V: 5000 mg/kg	No
Tetra, penta, hexa, and heptabromodiphenyl ether	POP Regulation, Annex A as amended by Commission Regulation (EU) No 757/2010.	Substance occurring as an unintentional trace contaminant concentrations are allowed to be equal to or below 10 mg/kg (0.001 % by weight) in substances, preparations, articles or as constituents of the flame-retarded parts of articles Products and preparations containing one of the four PBDEs covered in a concentration below 0.1 % by weight when produced partially or fully from recycled materials or materials from waste prepared for re-use, unless such waste is regulated by the RoHS Directive. The use of products already in use before 25 August 2010 which have tetra, penta, hexa and heptabromodiphenyl ether as a constituent.	Commission Regulation (EU) 756/2010 and Commission Regulation (EU) no. 2014/1342 Annex IV: Tetrabromodiphenyl ether, pentabromodiphenyl ether, hexabromodiphenyl ether and heptabromodiphenyl ether: 1 000 mg/kg Annex V: Tetrabromodiphenyl ether, pentabromodiphenyl ether, hexabromodiphenyl ether and heptabromodiphenyl ether: 10 000 mg/kg;	No
Technical endosulfan and its related isomers	POP Regulation, Annex A as amended by Commission Regulation (EU) No 519/2012. Related ban for plant protection products containing endosulfan; Regulation (EC) 396/2005, latest revised by Regulation (EU) 310/2011.	Placing on the market and use of articles already in use before or on 10 July 2012 containing endosulfan as a constituent of such articles shall be allowed.	50mg/kg (annex IV) 5000 mg/kg (annex V) Commission Regulation (EU) no. 2014/1342	No

Substance – Ban on production, marketing and use	Instruments	Current specific exemptions*	Limit value in waste**	Supplemental Danish legislation
PCB	Original POP Regulation, Annex A as amended by Commission Regulation (EU) No 757/2010.	Without prejudice to Directive 96/59/EC, articles already in use at the time of the entry into force of this Regulation are allowed to be used	50mg/kg Commission Regulation (EU) 1195/2006 and Commission Regulation (EU) 172/2007	Statutory Order on PCB/PCT no 47 of 12/01/2016 implementing the PCB/PCT Directive 96/59 to which the POP Regulation refers All use of PCB was banned as at 1 November 1986 *(former Statutory Order no. 718 of 9 October 1986)*.
PFOS[8]	POP Regulation, Annex A as amended by Commission Regulation (EU) No 757/2010.	Unintentional trace contaminant in substances and preparations in (i) concentrations of PFOS of 10 mg/kg (0.001% by weight) or less, (ii) semi-finished products or products or parts thereof, if the concentration of PFOS is lower than 0.1% by weight, or for textiles or other coated materials, if the amount of PFOS is lower than 1 μg/m^2 of the coated material. Use of products already in use before 25 August 2010 and containing PFOS as a constituent is allowed Until new information and safer alternative occur, processes concerning photolithography, photographic coatings, mist suppressants, and hydraulic fluids for aviation are allowed.	50mg/kg Commission Regulation (EU) No 756/2010 as amended by Commission Regulation (EU) no. 2014/1342	No

* Exemptions which are outdated are not included in this table. The table provides an overview. For the detailed requirements involved, please refer to the EU legislation mentioned.

** Conditions for applying the limit value in Annex V, Part II are described below under *Management of waste containing POPs.*

2.2.5.5 Release reduction of unintentionally formed POPs

The POP Regulation requires Denmark and the other EU Member States to prepare and update lists of releases of dioxins, PCB, HCB and pentachlorobenzene to air, water and soil, respectively. Moreover, Denmark and the other EU Member States must prepare and implement national action plans which are to identify, describe and minimise releases of such substances.

[8] Unlike the Convention, the Regulation does not differentiate between specific exemptions and acceptable purposes but operates solely using specific exemptions. The Regulation lists five specific exemptions for production, marketing and use of PFOS, alone as well as included in preparations or products. Such exemptions correspond to some of the acceptable purposes listed in the Convention. The exemptions in the Regulation are thus limited compared with the Convention.

Relevant legislation to minimise or prevent releases of unintentionally produced POPs and the categories of releases addressed by legislation are included in TABLE 6 below.

With regard to POPs formed unintentionally, EU legislation as well as Danish environmental protection legislation apply a number of instruments which help reduce release of these substances.

The most important release reduction measures are laid down in the IE Directive (Industrial Emissions Directive, directive 2010/75/EU). The Directive entered into force on 6 January 2011 and was implemented in Danish law by 6 January 2013 through amendments of acts and statutory orders.

The IE Directive has been implemented mainly through the Environmental Protection Act (Da: Miljøbeskyttelsesloven) and the Statutory Order on Approval of Listed Activities (Da: Godkendelsesbekendtgørelsen). The Environmental Protection Act is based on the fundamental principle that pollution of surroundings must be prevented or limited as much as possible. On the basis of this principle, the Environmental Protection Act requires individual enterprises to use best available techniques (BAT) so that overall pollution is minimised. In association with the IE Directive, the EU prepares reference documents describing the techniques considered as BAT. These reference documents are part of the foundation for approval and supervisory authorities' administration of the Environmental Protection Act.

The air guidelines of the Danish EPA from 2001 (Da: Luftvejledningen) which are used for environmental approval of enterprises, include provisions on primary group I substances, which are particularly hazardous substances, including POPs.

Provisions on waste incineration in the Statutory Order on Waste (Da: Affaldsbekendtgørelsen) and the Statutory Order on Waste Incineration Plants (Da: Affaldsforbrændingsbekendtgørelsen) cover a very significant source of unintentional formation of POPs. According to the Statutory Order on Waste, burning of waste is only permitted in plants approved for the purpose. This provision should be viewed in context with the provisions in the Statutory Order on Waste Incineration Plants on design and operation of incineration plants and co-incineration plants, including requirements for limit values for air emissions.

The Statutory Order on Waste Management in the form of Motor Vehicles and Derived Waste Fractions (Da: Bilskrotbekendtgørelsen), implementing EU Directive 2000/53 on end-of-life vehicles, requires dangerous components to be removed from vehicles before the chassis is dismantled, and appropriate disposal of shredder waste. This requirement helps reduce emissions of POPs from shredder plants.

In addition, the Statutory Order on placing on the market of electrical and electronic equipment and management of waste electrical and electronic equipment (Da: Elektronikaffaldsbekendtgørelsen), implementing EU Directive 2012/19 on waste electrical and electronic equipment (WEEE), requires that components containing PCB in scrap electrical and electronic equipment must be removed from the products and destroyed. This requirement reduces the risk of formation of dioxins in connection with waste treatment. Furthermore, it requires that plastics containing brominated flame retardants (including the PBDEs and HBCDD) is disposed of using companies that have approval for management of bromine-containing waste.

Finally, pursuant to the Water Framework Directive, PAH, hexachlorobenzene, hexachlorobutadiene and pentachlorobenzene are listed as priority hazardous substances which are subject to emissions control and environmental quality requirements.

With the PRTR Regulation (Pollutant Release and Transfer Register), coherent, integrated, national registers of releases and transfer of pollutants (PRTR) were established in the EU Member States. The registers cover all unintentionally formed POPs except the chlorinated naphthalenes. It also covers inventories of releases from diffuse sources.

TABLE 6. Instruments for release reduction from unintentional formation of POPs

Instrument	Source categories affected by the instrument (with description of the source category according to Annex C of the Convention)	Strategy for release reduction
ANNEX C, Part 2 (Stockholm Convention) source categories		
Statutory Order on Waste Incineration Plants	a) Waste incineration plants	Stipulation of limit value for releases of dioxins of 0.1 ng I-TEQ/Nm^3 In plants that burn hazardous waste of more than 1% halogenated organic compounds, expressed as chlorine, temperature must reach a minimum of 1,100 °C for at least 2 seconds
Statutory Order on Waste	a) Waste incineration plants	Restricts disposal of PVC in incineration plants Restricts disposal of waste oils for incineration Requirements on establishing collection scheme for PVC waste
Danish Government Waste Strategy 2013-2018	a) Waste incineration plants	Limits on waste amounts
Environmental Protection Act Guidelines for industrial air pollution control	b) Cement kilns firing hazardous waste	Requirement to use best available techniques (BAT) with recommended limit value for releases for dioxins of 0.1 ng I-TEQ/Nm^3 and for PCB of 0.1 µg/Nm^3 (sum of PCB_6)
Statutory Order on Waste	b) Cement kilns firing hazardous waste	Requirements on establishing collection scheme for PVC waste
ANNEX C, Part 3 (Stockholm Convention) source categories		
Environmental Protection Act Guidelines for industrial air pollution control	b) thermal processes in the metallurgical industry not mentioned in Part 2 d) fossil fuel-fired power plants and industrial boilers e) large installations for incineration of wood and other biofuels g) crematoria i) destruction of animal carcasses l) degradation of copper cables	Requirement to use the best available techniques (BAT) and reduce the emissions as much as possible. Guiding limit value for emissions for dioxins of 0.1 ng I-TEQ/Nm^3, and for PCB of 0.1 µg/Nm^3 (sum of PCB_6). For dioxin-like PCBs the guidelines do not include a guiding limit value, but the standard method for measurements in accordance with the guidelines (MEL-15, 2015) includes a description of measurements down to 0.01 ng WHO-TEQ_{PCB}/Nm^3
Statutory Order on Waste Statutory Order on Waste Incineration	m) waste oil refineries d) fossil fuel-fired power plants and industrial boilers	Requirement that waste oil >50 ppm PCB must not be used as fuel Waste gas from waste oils incineration of more than 10 ppm PCB/PCT must, for at least two seconds during incineration, be exposed to a temperature higher than 1,200°C in the presence of at least 6% by volume of oxygen in the waste gas.
Statutory Order on PCB/PCT	m) waste oil refineries d) fossil fuel-fired power plants and industrial boilers	Ban on use of PCB/PCT in electrical equipment Restrictions on the disposal of waste containing PCB/PCT
WEEE Statutory Order	k) shredder plants for treatment of end of life vehicles (shredding	Requirement to remove capacitors containing PCB before dismantling electrical and electronic equipment in

	plant)	shredding plants
Statutory Order on Waste Management in the form of Motor Vehicles and Derived Waste Fractions	k) shredder plants for treatment of end of life vehicles (shredding plant)	Requirement to remove hazardous components from vehicles before dismantling the chassis and appropriate disposal of shredder waste
Statutory Order on ban on imports, sale, use and exports of products containing pentachlorophenol (PCP)	a) Open burning of waste c) Residential combustion sources Releases of dioxins from PCP-treated wood	Ban on use of pentachlorophenol (PCP) Limit value for PCP in mixtures and products
Statutory Order on Landfilling	a) Open burning of waste (Landfill fires)	Requirements for measures to eliminate risk of fire or explosion in stored waste

2.2.5.6 Releases from stocks

The provisions in the Convention on POP stocks have been implemented by the POP Regulation, which determines that POPs must be identified and managed appropriately in terms of the environment.

Management of any stocks before they become waste is covered by applicable chemicals legislation.

2.2.5.7 Management of waste containing POPs

Legislation concerning management of waste containing POPs is summarised in TABLE 7. The requirements in the Convention on waste management were implemented by the POP Regulation (Article 7 with accompanying Annexes IV and V), which includes a number of specific waste management provisions and is supplemented by a number of EU Directives on management, including landfilling of waste. The management requirements are implemented by the Statutory Order on Waste, the Statutory Order on Waste Management in the form of Motor Vehicles and Derived Waste Fractions, and the Statutory Order on Landfilling (Da: Deponeringsbekendtgørelsen).

According to the POP Regulation Article 7, producers and holders of waste must make all reasonable efforts to avoid, where feasible, contamination of waste with POPs. POP-substances in waste shall be destroyed or irreversibly transformed according to Article 7(2) and Annex V Part 1.

Exceptions to this general rule are:

1) waste containing or contaminated with POPs listed in Annex IV may be otherwise disposed of or recovered in accordance with other EU legislation (rather than through destruction or irreversible transformation), provided that the POP content in the waste is lower than the concentration limits in Annex IV. The limit values are listed in Appendix 1 to this NIP.

2) Waste listed in annex V with POP contents within the concentration limits determined in Annex IV and below the concentration limits set in Annex V may be deposited underground or in a landfill site for hazardous waste. However, it must be established that destruction or irreversible transformation of the content of persistent organic pollutants do not represent environmentally preferable options. The operation must also be in accordance with relevant Community legislation. Furthermore, the competent authority must have authorised the alternative operation. Finally, the other EU Member States and the European Commission must be notified about permission received to use the alternative operation. However, this operation is only possible for the waste fractions covered by Annex V. Please note that waste with POP contents above the concentration limit in Annex V may be deposited underground.

Landfilling of waste must be carried out in accordance with the regulations in the Landfilling Directive and the Danish Statutory Order on Landfilling. According to the Danish Statutory Order on Landfilling, PCB containing waste of <50 mg/kg dry matter and a maximum of 5% organic carbon may be disposed of in specific cells in landfills for mineral waste.

TABLE 7. List of regulation of management of waste containing POPs

Legislation relevant for management of waste containing POPs	Provisions relevant for POPs
The POP Regulation Regulation (EC) no. 850/2004	Waste containing or contaminated with POPs above certain concentration levels must be disposed of through destruction or irreversible conversion. Some POP-contaminated waste fractions may however also be stored underground.
WEEE Statutory Order	Separate collection of waste electrical and electronic equipment. Plastic containing brominated flame retardants is extracted in selective treatment of waste electrical and electronic equipment. Requirement to remove capacitors containing PCB before dismantling electrical and electronic equipment in shredding plants Implementing the WEEE Directive (Directive 2012/19/EU)
Statutory Order on Waste Management in the form of Motor Vehicles and Derived Waste Fractions	Requirement to remove hazardous components from vehicles before dismantling the chassis, as well as safe disposal of shredder Implement the ELV Directive (Directive 2000/53/EC)
Statutory Order on Waste	Requirement to screen for PCB and separate building and construction waste containing PCB. Waste containing dioxins, DDT, chlordane, hexachlorocyclohexanes (including lindane), dieldrin, endrin, heptachlor, hexachlorobenzene, chlordecone, aldrin, pentachlorobenzene, mirex, toxaphene, hexabromobiphenyl or PCB above the concentration limits defined in Annex IV to the POP Regulation is classified hazardous. Implement among others the Waste Framework Directive (Directive 2008/98/EC)
Statutory Order on Landfilling	Regulation on landfilling. Implement the Landfill Directive (Directive 1999/31/EC)
The Shipment Regulation Regulation (EC) no. 1013/2006	Shipment of waste within the EU containing, including or contaminated with substances listed in the Stockholm Convention requires written notification and written consent. Restrictions on import and export of waste containing POPs to and from specific countries.
Statutory Order on Waste Incineration Plants	Limit values for emission of dioxins of 0.1 ng I-TEQ/Nm^3 (would in practice also limit emission of other POPs). Incineration plants incinerating waste with more than 1 % halogenated organic substances should reach a temperature of at least 1,100 °C for at least 2 seconds. Implementing parts of the IE Directive (Directive 2010/75/EU), among others
Statutory Order on Residual Products	Lays down regulations on use of residual products and soil for building and construction and on use of separated uncontaminated building and construction waste from which sealant containing PCB must be separated. A limit value of 2.0 mg PCB_{total}/kg is applied (measured where the concentration is assessed to be the highest)

2.2.5.8 Special aspects on managing building and construction waste containing PCB

The Statutory Order on Waste lays down requirements on separation of building and construction waste, and separation of building and construction waste containing PCB. The provision states that enterprises producing waste must separate building and construction waste on site in the fractions listed in the provisions.

When enterprises producing waste separate their building and construction waste for further use, they must be sure to separate everything except mortar and any reinforcement iron. This means that sealant material containing PCB and other material containing PCB must be identified and separated. Furthermore, double-glazed windows which may contain glue containing PCB must be separated and destroyed or landfilled if they cannot be recycled; this is also the case for window panes containing PCB. The requirements of the Statutory Order on Waste for survey of PCB by renovation and demolition are further described in section 2.3.8.3.

The separation may be omitted if the total volume of waste from the relevant building and construction work does not exceed 1 tonne. In such cases, waste is assigned for separation by the municipality. The enterprise producing waste must ensure that building and construction waste containing PCB is identified and separated and that double-glazed windows are separated.

Management of building and construction waste containing PCB is regulated by the POP Regulation, which provides for landfilling of waste containing low concentrations of PCB. The Statutory Order on Waste sets requirement to separate building and construction waste containing PCB.

Use of separated, uncontaminated building and construction waste may take place according to the regulations in the Statutory Order on use of residual products and soil for building and construction (Da: Restproduktbekendtgørelsen) and on use of separated, uncontaminated building and construction waste, or according to the regulations in the Environmental Protection Act.

Landfilling of waste is otherwise regulated by the Danish Statutory Order on Landfilling (Da: Deponeringsbekendtgørelsen).

Based on interpretation of the POP Regulation and the Landfill Directive, Denmark manages building waste containing PCB (measured as PCB_{total}) as follows:

- Waste with a PCB concentration of more than 50 mg/kg must be classified as hazardous waste and destroyed in accordance with the POP Regulation. In practice this means that waste must be destroyed in an installation licensed to incinerate hazardous waste containing PCB. In special cases, waste containing more than 50 mg PCB/kg may be permanently stored underground, in cliff formations or in salt mines. These cases presuppose an assessment by the municipality justifying that such is the best solution for the environment and that the Danish EPA subsequently approves this solution (and notifies the European Commission and the other EU Member States about the deposit). Waste containing more than 50 mg PCB/kg may not be deposited in surface installations for hazardous waste.
- Waste with PCB concentrations of 0.1- 50 mg PCB/kg should preferably be destroyed in solid waste incinerators with permits to incinerate waste containing PCB. If this is not possible or otherwise not the preferable option, then:
  - Waste with PCB concentrations of 10-50 mg/kg may be landfilled in landfills for mixed waste
  - Waste with PCB concentrations of 1-10 mg/kg may be landfilled in landfills for mineral waste

  - Waste with PCB concentrations of below 1 mg/kg may be landfilled in landfills for inert waste
- Building waste with PCB concentrations of a maximum of 2.0 mg/kg (measured at source and in the surface where the concentration is considered to be highest) may be recovered under certain conditions after prior notification to the municipality
- Waste with PCB concentrations of below 0.1 mg/kg is considered uncontaminated.

2.2.5.9 Transboundary movement

Transboundary movement of waste, including waste containing, including or contaminated with POPs, is regulated by the Regulation on Shipment of Waste. All shipment of waste containing, including or contaminated with substances listed in the Stockholm Convention presupposes written notification and consent within the EU. All export of waste containing POPs from the EU is banned. This ban does not apply to export of waste for disposal in EFTA countries that are also parties to the Basel Convention. Imports into the EU are only permitted if they are from EFTA countries or countries which are party to the Basel Convention.

2.2.5.10 Provisions for POPs in food and animal feed

Legislation concerning POPs in food is summarised in TABLE 8.

Provisions for dioxin and PCB in food. EU limit values for the content of dioxin and PCB in food have been set. The limit values are stated in Commission Regulation (EC) 1881/2006 (as amended by Commission Regulation (EU) no. 1259/2011) by as regards maximum levels for dioxins, dioxin-like PCBs and non-dioxin-like PCBs in foodstuffs. In addition to limit values for dioxins and dioxin-like PCBs, this regulation also sets values for selected non dioxin-like PCBs.

Commission Recommendation 2013/711/EU of 3 December 2013 on the reduction of the presence of dioxins and PCBs in feed and food lays down action levels for these substances in order to stimulate a pro-active approach to reducing the presence of dioxins and dioxin-like PCBs in food (further amended by Commission Recommendation 2014/663/EU). The action levels are slightly lower than the limit values.

Due to high dioxin content in fish in the Baltic Sea Region, Denmark has introduced risk management measures for sales of certain fish species from the Baltic Sea and neighbouring seas, see Statutory Order no.1487 of 5 December 2017. The Statutory Order has replaced a previous ban on sales of certain fish species from the Baltic Sea.

Requirements for methods of sampling and analysis are established in Commission Regulation (EU) no. 644/2017 of 5 April 2017, which lays down methods of sampling and analysis for the official control of levels of dioxins, dioxin-like PCBs and non-dioxin-like PCBs in certain foodstuffs, repealing Regulation (EC) no. 589/2014.

Provisions on dioxins and PCB in feed. In parallel with the amendments to regulations on foodstuff, the legislation for dioxin and dioxin-like PCBs in animal feed have also been amended. Directive 2002/32/EC on undesirable substances in animal feed includes general rules on undesirable substances. This Regulation sets limit values on animal feed for 1) the sum of dioxins, 2) the sum of dioxins and dioxin-like PCBs and 3) certain non-dioxin-like PCBs, respectively. The Regulation also sets action thresholds for dioxins and dioxin-like PCBs, respectively. For dioxins and dioxin-like PCBs, the general rules from the Directive on undesirable substances are implemented by Statutory Order no. 935 of 27 June 2018 on animal feed and animal feed companies which, among other stipulations, determines that animal feed containing undesirable substances in larger volumes than the maximum content in Annex I to Directive 2002/32/EC may not be placed on the market or used as animal feed.

Requirements for methods of sampling and analysis for the official control of animal feed are regulated by Commission Regulation (EC) no. 709/2014 amending Commission Regulation (EU) no. 278/2012.

In addition to the regulations on limit values for dioxins, Regulation no. 183/2005 laying down requirements for feed hygiene, last amended by Commission Regulation (EU) 2015/1905 as regards the dioxin testing of oils, fats and products derived thereof establishes special regulations on approval of establishments which market certain products for use as animal feed made from vegetable oils and fats, and on special requirements for manufacture, import, storage and transport of oils, fats and derivative products thereof. The Regulation lays down requirements for dioxin monitoring, including specific frequencies of analyses that establishments are required to carry out in accredited laboratories for the sum of dioxins and dioxin-like PCBs in such products and documentary proof to follow the products. The special provisions are laid down in Commission Regulation no. 225/2012 and Commission Regulation (EU) 2015/1905.

Health risks to humans due to food or feed (Rapid Alert System for Food and Feed, RASFF). The “rapid alert system” that provides information about direct or indirect health risks to humans due to food or feed (Rapid Alert System for Food and Feed, RASFF) ensures effective exchange of information between EU authorities on any presence of POPs in food and animal feed. The system was established by Regulation (EC) no. 178/2002 of 28 January 2002, which lays down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety, as well as Commission Regulation 16/2011 of 10 January 2011, which lays down implementing measures for the Rapid Alert System for Food and Feed. The detailed monitoring methods for traces of brominated flame retardants in food is provided by the EU Commission in Recommendation 2014/118 of 3 March 2014.

Provisions on pesticide residue in food and feed. Furthermore, EU limit values have been set for the content of pesticide residue in food and animal feed. Limit values are laid down in Regulation (EC) no. 396/2005 of the European Parliament and of the Council on maximum residue levels of pesticide residue in or on food and feed of plant and animal origin (latest amended by Commission Regulation 2018/70 of 16 January 2018). Maximum residue levels for pesticide residue (MRL) comprise specific maximum residue levels for a number of combinations of substances and crops. For all pesticide-crop combinations without specifically set maximum residue levels, a detection limit of 0.01 mg/kg automatically applies as the maximum residue level.

The goal is to ensure that the content of pesticide residues in food and feed do not represent an unacceptable risk for the health of consumers and animals.

TABLE 8. Overview of regulation of POPs in food and feed

Legislation concerning POPs in food and feed	Provisions relevant for POPs
Commission Regulation (EU) no. 1259/2011	EU maximum levels for dioxins, dioxin-like PCBs and non-dioxin-like PCBs in foodstuffs.
Commission Recommendation of 3 December 2013	On the reduction of the presence of dioxins and PCBs in feed and food as well as action levels for dioxins and dioxin-like PCBs in feed and food.
Statutory Order on feed and animal feed enterprises	Animal feed containing undesirable substances in quantities greater than maximum content (dioxins, PCB and pesticide residue) as stated in Annex I of Regulation nos. 574/2011 and 277/2012 may not be placed on the market

Legislation concerning POPs in food and feed	Provisions relevant for POPs
	or used as animal feed.
Commission Regulation (EU) No. 2015/786	Defining the acceptable criteria for detoxification processes, which can be used on feed, which does not comply with the limit values in directive 2002/32/EC
Commission Regulation (EU) no. 644/2017. Commission Regulation (EC) no. 152/2009 as amended by Commission Regulation (EU) no. 709/2014	Requirements for methods of sampling and analysis of the content of dioxins, dioxin-like PCBs and non-dioxin-like PCBs in food and animal feed.
Regulation (EC) no. 178/2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety.	Stipulates regulations for the so-called rapid alert system notifying direct or indirect health risks for humans due to food or animal feed (Rapid Alert System for Food and Feed, RASFF).
Statutory Order on management measures by sales of certain fish species from the Baltic Sea Region Statutory Order no.1487 of 5 December 2017.	Management measures for sales of certain fish species from the Baltic Sea and neighbouring seas
Regulation (EC) no. 396/2005 on maximum residue levels for pesticide residue in or on food and feed of plant and animal origin	Maximum residue levels for pesticide residue (MRL) comprise specific maximum residue levels for a number of combinations and crops. For all pesticide-crop combinations without specifically set maximum residue levels, the detection limit of 0.01 mg/kg automatically applies as maximum residue level.
Commission Regulation (EU) no. 225/2012	Amending Annex II of Regulation (EC) no. 183/2005 of the European Parliament and of the Council as regards the approval of establishments placing on the market, for feed use, products derived from vegetable oils and blended fats and as regards the specific requirements for production, storage, transport and dioxin testing of oils, fats and products derived thereof.
Commission Regulation (EU) 2015/1905	Amending Annex II to Regulation (EC) No 183/2005 of the European Parliament and of the Council as regards the dioxin testing of oils, fats and products derived thereof.

This Regulation is supplemented by Directive 2002/32/EC on undesirable substances in animal feed. For the substances aldrin, dieldrin, camphechlor, chlordane, DDT, endosulfan, endrin, heptachlor, hexachlorocyclohexane and hexachlorobenzene, the maximum residue levels in Commission Regulation 574/2011, Annex I, Part IV apply. Pursuant to Statutory Order no. 935 of 27 June 2018 on animal feed and feed establishments, animal feed containing undesirable substances in larger quantities than the limit values must not be placed on the market or used as animal feed. However, Regulation No. 2015/786 defines the acceptable criteria for detoxification processes that can be used on feed that does not comply with the limit values in Directive 2002/32/EC, Annex I. It stipulates that establishments covered by Regulation (EC) No 183/2005 that carry out a detoxification process shall be approved in accordance with Regulation (EC) No 183/2005. This is supplemented by specific labelling requirements of contaminated materials intended to be reduced or eliminated by cleaning as in Regulation 767/2009.

2.3 The POP situation in Denmark

This section includes a description of the POPs situation in Denmark.

For the six newly added substances, a more detailed general description is included on the production and current use and supply of the substance, historical use and supply as background for the assessment of the substance in waste, concentration in food and drinking waste, human exposure and risk, and releases to the environment and environmental concentrations.

For the other substances, a similar description can be found in the two previous NIPs. In this NIP, the focus is on information that has become available since the last implementation plan and new issues which have emerged.

The substance-specific sections are followed by a section on stocks, waste and contaminated sites which summarise the information and discuss some issues common across the substances. In the previous NIPs, the substance-specific waste-related issues have also been included in this section, but in order to avoid that the same information is included twice and to keep the substance-specific information together, it has been decided to include information on waste in the substance-specific sections.

This section is followed by sections on need for exemptions, monitoring programmes, information for the public, activities by NGOs, technical infrastructure, particularly exposed population groups and systems for assessment of new substances.

Potential occupational exposure is not systematically described, but occupational exposure where workers may be exposed at significantly higher levels that the general population is described in section 2.3.18.1.

2.3.1 Hexachlorobutadiene (HCBD)

2.3.1.1 Production of HCBD in Denmark

HCBD has never been manufactured in Denmark, at least not at commercial scale, either by direct synthesis from butane or butadiene or as a by-product from the manufacturing of chlorinated solvents such as carbon tetrachloride or tetrachloroethylene (neither of these solvents were ever produced in Denmark).

2.3.1.2 Current use and supply of HCBD

There is no current use of HCBD in Denmark or in the EU and there have been no intentional uses of the substance in Europe for many years (ESWI, 2011).

2.3.1.3 Historical use and supply of HCBD in Denmark and the EU

Historically, HCBD has been used as an intermediate in the manufacture of rubber compounds, and in the production of chlorofluorocarbons and lubricants (ESWI, 2011). Lesser quantities have been used as solvents e.g. for chlorine, and for transformer oils and hydraulic fluids, fluid for gyroscopes, heat transfer fluid and washing liquid for removal of hydrocarbons from gas streams (Lecloux, 2004). Formerly, HCBD was used extensively as a pesticide, in particular for protection of grapevines against the parasitic insect pest *Phylloxera* (Lecloux, 2004) in EU countries such as France, Greece, Italy and Spain.

There is no information indicating that intentional use of HCBD should ever have taken place in Denmark, either for industrial purposes or as a pesticide. A search in the Danish Product Register made in connection with a screening of substances under evaluation in the latest update of the NIP for the Stockholm Convention in 2012 did not reveal any uses of HCBD in Denmark at that time.

According to information provided by ESWI (2011), HCBD has been intentionally produced for several uses in Europe in the past. The production in Europe of HCBD for commercial use stopped in the late 1970s (ESWI, 2011). However, ESWI (2011) reports use of HCBD as an insecticide in viticulture in France as late as in 2003. As mentioned above, HCBD has been formed as a by-product in the production of carbon tetrachloride and tetrachloroethylene.

The approximate annual global production volume in 1988 was reported by ESWI (2011) to be 2,000 to 4,000 tonnes.

2.3.1.4 HCBD in waste

HCBD may occur in various waste streams mainly as a result of the unintentional production of the substance in a range of industrial manufacturing processes, mainly within the chlorine, plastic and magnesium industries. (ESWI, 2011). In ESWI (2011), based on E-PRTR reporting data, the releases of HCBD to water in the EU as a whole were estimated to be about 140 kg in 2008, 84 kg of which was released directly from manufacturing industries (basic organic chemicals production 60 kg; plastics industry 24 kg), while WWTPs accounted for 29 kg and hazardous waste disposal and/or recovery facilities, 27 kg. None of these processes have been identified in Denmark, and no HCBD waste is expected to be generated.

HCBD concentrations in emissions from MSW incineration plants are not measurable; they are below the analytical detection limit.

In wastewater and in emissions from landfills as well, the concentrations of HCBD typically appear to be below the detection limit (Scheutz & Kjeldsen, 2010). In a Danish study of pollutants in municipal sewage sludge from several WWTPs (VKI, 1996), HCBD could not be detected in any of the 11 analysed samples from different treatment plants, the Limit of Detection (LOD) being 1 µg/kg dw.

No Danish data on the content of other HCBD sewage sludge have been identified.

2.3.1.5 HCBD in food and drinking water

No data on the presence of HCBD in drinking water in Denmark have been identified. HCBD is also not included in the Danish control programme for micro-pollutants in food.

In a Danish study of HCBD among other substances in aquatic biota (Strand *et al.* 2010), about 50 samples of bivalves, fish, and fish-eating birds and aquatic mammals (both marine and freshwater fauna) were analysed for their content of HCBD. HCBD could not be detected in any of the samples using a method with a LOD (limit of detection) of 0.27 µg/kg ww (wet weight). The report refers to an EU limit of 12.2 µg HCBD/kg ww in aquatic food items intended for human consumption.

Euro Chlor (2004) reports low levels of HCBD in various food items of both animal and plant origin from the United Kingdom and Germany ranging from non-detectable up to 42 µg/kg; most of the reported concentrations were in the low µg/kg range. The reported values were from investigations carried out in the 1970s.

A TDI for oral intake of HCBD of 0.0002 mg/kg-d has been calculated by the US EPA POPs-toolkit[9] and is equal to the WHO TDI published in its guideline for drinking water quality, which also comprises a guideline value for HCBD in drinking water of 0.6 µg/L[10].

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[9] http://www.popstoolkit.com/tools/HHRA/TDI_USEPA.aspx

[10] http://www.who.int/water_sanitation_health/publications/2011/9789241548151_ch12.pdf

2.3.1.6 Total human exposure in Denmark

No surveys or assessments of the total exposure of humans in Denmark to HCBD have been identified.

Not many quantitative data on the occurrence of HCBD in food types or drinking water in Denmark (or elsewhere) are available, and the few identified data from other countries are several years old. However, the available data indicate that the current exposure of humans in Denmark to HCBD via food and drinking water is negligible.

The limited amount of data on exposure of humans from other sources such as the working environment, indoor environment etc. also do not indicate any appreciable exposure of humans from such sources.

2.3.1.7 Releases of HCBD and presence in the environment

HCBD is not included in any of the national Danish environmental monitoring activities such as e.g. the NOVANA programme. Releases to the environment via the major waste streams from society (e.g. municipal wastewater, emissions from MSW (municipal solid waste) incineration, landfills) appear to be so low that monitoring of HCBD is not seen as relevant.

As mentioned above, Strand *et al.* (2010) investigated the content of HCBD in various species of marine and freshwater fauna (bivalves, fish, and fish-eating birds and mammals) but did not find HCBD above the LOD of 0.27 µg/kg ww in any of the approximately 50 samples that were analysed. The authors refer to the main results from a previous Danish study (2008-2009) of HCBD in marine sediments from mainly coastal waters. HCBD was detectable in only 11 out of 86 analysed samples; the mean level in the 11 samples was 0.08 µg/kg dw (dry weight) with a maximum of 0.23 µg/kg dw. There was no apparent correlation between the findings of HCBD in sediments and proximity to larger towns located on the coast.

2.3.2 Decabromodiphenyl ether (decaBDE)

A survey of decaBDE and other brominated flame retardants was undertaken as part of the Danish EPA's surveys of substances on the List of Undesirable Substances - LOUS (Lassen *et al.* 2014b). Based on the results of the survey, the Danish EPA developed a strategy for brominated flame retardants (Danish EPA, 2014). The strategy listed a number of measures which mainly focused on brominated flame retardants which had not been restricted. Of relevance here were some measures addressing alternative methods for obtaining fire protection without the use of halogenated flame retardants.

2.3.2.1 Production of decaBDE in Denmark

According to the available information, decaBDE has never been produced in Denmark. However, the substance has been imported in limited amounts as a chemical (about 5 t/year; Lassen *et al.*, 1999), but the by far biggest amounts in Denmark occur because of the use of decaBDE as a component in imported articles.

2.3.2.2 Current use and supply of decaBDE

According to the Danish EPA's LOUS survey of brominated flare retardants (Lassen *et al.* 2014b), a breakdown of the consumption of decaBDE by application area in the EU is not available. The LOUS survey refers to information from the USA indicating that the main application areas are 'automotive and transportation' (26%), 'building and construction' (26%), 'textiles' (26%), electrical and electronic equipment' (13%) and 'others' (9%). Lassen *et al.* (2014b) consider that use in 'electrical and electronic equipment' is lower in the EU because of the restrictions in the RoHS Directive.

DecaBDE has been considered the cost-effective all-round brominated flame retardant for a long time; the REACH Annex XV dossier for decaBDE (ECHA, 2012) mentions a range of application areas for the substance within two main categories, polymeric applications and textile applications (other flame retardants can also be used for many of the mentioned applications).

Polymeric applications (typically at concentrations of 10-15%):
- Polyolefin polymers, e.g. PE, PP, PPE and EVA, used for power cables, insulation of wires, conduits, stadium seating, electrical connectors and boxes, heat shrinkable material, shipping pallets and roofing membranes.
- Styrenics, e.g. HIPS, ABS and PPO/PS.
- A number of engineering plastics, e.g. polyesters, polyamides, polyimides, polycarbonate and melamine.
- Thermosets such as UPS.
- Elastomers such as EPDM rubber, SBR rubber, TPU and EVA.
- Various water-based emulsions and coatings.

Textile applications:
DecaBDE is a versatile flame retardant that can be used to treat a wide range of natural, blended and synthetic fibres. It is therefore useful for treating some of the most popular upholstery materials used at present: mixtures of polyester, acrylic and viscose fibres. It is also used for window blinds, curtains, tents, indoor fabrics in cars etc., although upholstery is probably the application area with the highest volume. DecaBDE is not used in textiles for clothing, bedding or protective clothing where there is risk for prolonged contact with skin.

The LOUS review of brominated flame retardants (Lassen *et al.*, 2014b) lists a large number of specific applications of decaBDE within the following main categories:
- Electrical and electronic equipment (EEE)
- Ships, boats, airplanes
- Textiles and furniture
- Automobiles/mass transportation
- Household
- Public, private and industrial buildings/construction applications.

As mentioned below, use of decaBDE in in concentrations exceeding 0.1% by weight in articles and mixtures are banned effective 2 March 2019. A concentration of 0.1% is far below the concentration of decaBDE intentionally added to plastics in order to provide flame retardancy, but decaBDE may be present in recycled plastics in the future.

A recent investigation of decaBDE, octaBDE and HBCDD in plastics from toys and other consumer products in 19 countries including Denmark found decaBDE in 92% of the samples (concentration range: 1-3310 mg/kg), octaBDE in 86% of the samples (1-161 mg/kg) and HBCDD in 41% of the samples (1-207 mg/kg) (Straková *et al.*, 2018). Overall, the results demonstrate that the flame retardants in recycled plastics from WEEE find their way into consumer products sold on the European market (Straková *et al.*, 2018).

Implications of legislation on the use of decaBDE:
As a result of the RoHS Directive (Directive 2002/95/EC recast into Directive 2011/65/EU), and the implementation hereof into Danish legislation through Statutory Order 873 of 11/08/2006 (latest version: No. 327 of 14/04/2018), the use of decaBDE in electrical and electronic equipment within the scope of the RoHS Directive ceased in the EU in 2008. For a period of time decaBDE was subject to an exemption at EU level, but the exemption expired on 30 June 2008.

Through Commission Regulation 2017/227 of 10/02/2017, decaBDE is listed in REACH Annex XVII (Entry 67) and, with a few exceptions (mainly use in aircrafts), the manufacture or placing on the market of the substance is thereby banned effective 2 March 2019 as a substance on its own, in another substance, as a constituent, as a mixture or in an article in concentrations exceeding 0.1% by weight.

2.3.2.3 Historical use and supply of decaBDE in Denmark and the EU

Historically, at a global scale, for many years decaBDE was the most important substance within the group of brominated diphenyl ethers. Thus, in 1992, it constituted about 75% of the global consumption of PBDEs (40,000 t/year); the PBDEs (penta-, octa- and decaBDE) were estimated to constitute about 30% of the total consumptions of brominated flame retardants (BFRs). In the Danish substance flow analyses from 1999 (Lassen *et al.*, 1999), the penta-, octa- and decaBDE were aggregated, but as most of the PBDEs were present in imported articles, likely the decaBDE constituted the majority of the estimated quantities of PBDE.

In Western Europe, the consumption of PBDEs was high until the mid- or late 1990s. Thus, in 1996, PBDEs still accounted for 26% of the European consumption of brominated flame retardants, but in 1998 this figure had decreased to about 11% (Lassen *et al.*, 1999), in particular as a result of decreasing demand in Germany, the Netherlands and the Nordic countries. The manufacture of PBDEs in Germany ceased in 1986.

All decaBDE used in Denmark came from import of the substance, either as a chemical or in plastic raw materials/semi-manufactures, or with manufactured goods. According to Lassen *et al.* (1999), in 1997 Danish import of PBDEs, most of which was decaBDE as a chemical, in plastic raw materials or as semi-manufactures was only 1.1-1.2 tonnes out of a total import of BFRs within this category of 260-390 tonnes. According to the survey, decaBDE and other PBDEs were largely phased out in Danish production of plastic components for electronic equipment due to occupational health concerns with regard to antimony trioxide, used as a synergist flame retardant along with the PBDEs. By far the largest amount of PBDEs in 1997 was imported with manufactured goods (30-120 tonnes). The total import of brominated flame retardants to Denmark with manufactured goods was 320-660 tonnes in 1997 (Lassen *et al.*, 1999).

A breakdown of the total figures can be found in TABLE 9 below. The table also includes the data for HBCDD, further discussed in section 2.3.6.

No detailed data on the use of decaBDE in Denmark in recent years are available. As mentioned in the LOUS survey (Lassen *et al.*, 2014b), the total volume of decaBDE sold in Europe in 2014 was 2,500-5,000 t/year, which was a decrease from a level of 5,000-7,500 t/year in 2007. The split between main applications around 2010 suggests that approximately 4,500 t/year were used in plastics/polymers and 2,250 t/year were used in textiles. If the consumption in Denmark was at the average per capita level in the EU in 2010, the total content of plastics would be approximately 45 tonnes.
Textile applications likely account for minor amounts in Denmark, as a significant amount of decaBDE used for textiles in the EU goes to UK and Irish markets, as these countries have strict requirements on use of flame retardants in upholstery (UK, 2012).

TABLE 9. Consumption of brominated flame retardants in Denmark in 1997 with manufactured goods (from Lassen *et al.*, 1999)

Product Category	Consumption of all BFRs		Consumption of PBDEs	Consumption of HBCDD
	Tonnes	%	Tonnes	Tonnes
Printed circuit boards	100-180	29	0.3-5.2	0
Housing of electrical and electronic equipment	80-130	21	3-10	0
Other components of electrical and electronic appliances and machines	20-50	7	5-14	0
Lighting	4-14	2	1-7	
Wiring and power distribution	30-80	11	7-29	2-4
Textiles	2-11	1,3	0-5	2-9
Building materials	50-100	15	1-5	13-36
Paints and fillers	0.6-1.7	0.2	0.1-0.5	
Transportation	30-90	12	13-46	9-30
Other uses	0-3	0.3	0-2	0-2
Total	320-660	99	30-120	26-80

2.3.2.4 DecaBDE in waste

Solid waste. The major part of decaBDE in Denmark has entered the country with manufactured goods, historically largely in components of EEE, vehicles and building materials. Later the use of decaBDE in EEE ceased as a result of the RoHS Directive, but many of the articles where decaBDE was used as flame retardant may still be present in Danish society and will gradually enter waste streams, primarily for solid waste (WEEE).

According to the *WEEE Statutory Order* no. 1296 of 8 February 2018, components with more than 5 mg/kg (ppm) of brominated flame retardants must be removed selectively and disposed of at an enterprise approved to manage waste-containing brominehe majority of WEEE is exported for reprocessing in other EU countries after a pre-processing treatment in Denmark. According to the statistics on WEEE and BAT from the DPA system, which administers Danish producer responsibilities, in 2017 around 45,000 tonnes WEEE underwent pre-processing in Denmark while around 25,000 tonnes were treated in other EU Member States. No waste has been registered as being treated outside the EU since 2008.

TABLE 10. Disposal of decaBDE in post-consumer waste in Denmark

Product group	Typical concentration in materials *1	Potential quantities of decaBDE, t/y *3	Main disposal method in Denmark
Electrical and electronic equipment	10-15 % (higher for some applications) 6-7% (rubber cables)	10-100	WEEE treatment.
Building materials of plastics	10-15 %	1-5	Municipal solid waste incineration
Transportation - textile, electrical parts, other flame retarded parts	10-15 % i plastic parts 7.5-20% in textiles *2	1-10	Disposed of with shredder waste which is incinerated or landfilled Electrical parts disposed of for WEEE treatment

*1: Source: Lassen *et al.*, 1999; *2: Quantities roughly estimated on the basis of the quantities of decaBDE used in Denmark in 1997 and more recent information on the use in EU (as summarised in Lassen *et al.*,2014b)

Besides the export of WEEE, some second-hand electrical and electronic equipment are exported for reuse abroad. The total quantities of exported second-hand electrical and electronic equipment were estimated at 3,000-7,000 t/y in 2014 (Bauer *et al.*, 2016). About 1000 t/year was exported to countries outside the EU, with Lebanon as the major export market (mainly washing machines).

The decaBDE concentration in analysed shredder waste from Denmark was below the detection limit of 100 mg/kg in all fractions (Hyks *et al.*, 2015)

To the extent the equipment is taken apart in Denmark, plastic components with brominated flame retardants are disposed of for waste incineration.

Fate by incineration. The actual destruction efficiency for PBDEs in Danish incineration plants is currently under evaluation in an assessment for the Danish EPA.

A Swedish assessment of destruction efficiencies of MSW incinerators reach the conclusion that the available data for PBDEs indicate that PBDEs are destroyed even in MSW incinerators but the level of confidence for PBDE destruction is low due to the limited number of studies (Lundin and Jansson, 2017).

Wastewater. Due to their application and use pattern, PBDEs are also released to the public sewage system from industrial point sources as well as from diffuse sources. However, few quantitative data on this subject are available but, because of its physico-chemical properties, the substance would mainly be distributed to the solid phase (sludge) in wastewater treatment plants (WWTPs).

In 2015, decaBDE was analysed in treated municipal wastewater effluent from 10 different WWTPs in connection with the NOVANA point source monitoring programme (Danish EPA, 2017). With a LOD of 0.01 µg/L, decaBDE was not observed in any of the analysed samples.

In an analysis of all the sewage effluent monitoring data generated from 1998 to 2013 under the national Danish water environment surveillance programme, NOVA/NOVANA, the Danish Nature Agency published "National mean concentration" (NMC) values for several contaminants in treated sewage effluent (Naturstyrelsen, 2014). For decaBDE (BDE#209), the NMC value was set to zero, i.e. below the detection limit of 0.01 µg/L, as the substance was only detected in two out of 149 effluent samples that were analysed for BDE#209.

Sewage sludge. Jensen *et al.* (2012) refer to a Danish study on sewage sludge from 2003 in which decaBDE constituted 53% of the total PBDE concentration of 458 µg/kg dw in sewage sludge from a Danish municipal WWTP, corresponding to 258 µg decaBDE/kg dw. Assuming the same distribution, Jensen *et al.* (2012) estimated a level of decaBDE of 200-250 µg/kg dw in sludge from an earlier study carried out by Aarhus County at two WWTPs in the Aarhus area, where four other BDEs were observed in total concentrations ranging from 51-92 µg/kg dw. According to the authors, these results are reasonably in line with other results from Scandinavia and Western Europe.

Due to lack of data, the risk evaluation of brominated flame retardants in sewage sludge in Denmark by Jensen *et al.* (2012) was carried out for BDE#209 (decaBDE) and TBBPA (tetrabromobisphenol A) only. For the risk evaluation, Jensen *et al.* (2012) used a concentration of BDE#209 of 0.75 mg/kg d.w. Based on the exposure model, steady-state soil concentrations (PECs) for BDE#209 were predicted to be 0.011 mg/kg after multiple sludge applications. This predicted concentration is at the lower end of the observed concentrations reported for agricultural fields amended with large amounts of sewage sludge for multiple years. According to the authors, such scenarios are, however, no longer valid for a typical situation in Denmark, where sludge amendment of agricultural land is strongly regulated.

An additional margin of safety may, however, be needed in order to encompass the possibility of higher soil concentrations in areas that are not in compliance with e.g. the Danish sludge regulations, or areas receiving sludge from WWTPs treating wastewater specifically from industries producing or making use of brominated flame retardants (Jensen *et al.*, 2012). Based on a comparison between the lowest test concentration, where no significant effects were observed (NOEL), and the predicted concentrations in soils after multiple sewage sludge amendment, a margin of safety (MoS) was estimated at 9091 for BDE#209. On this basis, it was concluded that it was unlikely that the levels found in Danish sludge should pose a significant risk to soil dwelling organisms and soil quality in general, if the current application guidelines of sewage sludge are followed (Jensen *et al.*, 2012). The study did not include an assessment of the combined exposure to all the PBDE.

2.3.2.5 DecaBDE in food and drinking water

According to the LOUS review of brominated flame retardants (Lassen *et al.* 2014b), no data on decaBDE nor other PBDEs in Danish drinking water are available. No newer data have been identified.

A recent study (2015) by the Danish Veterinary and Food Administration (DVFA, 2015) of brominated compounds in Danish farmed fish did not include PBDEs. However, the LOUS review of BFRs refers to analyses by the same agency from 2009 and 2010, in which samples of beef, pork, lamb, milk and eggs were examined for the contents of PBDEs. All samples were found to have PBDE levels just below the tolerable level of 100 ng/g fat.

DecaBDE is not included in the reviews of the 2004-2011 and 2012-2014 national food monitoring data (Petersen *et al.*, 2015a; Petersen *et al.*, 2015b).

A European level monitoring programme comprising 19 PBDE congeners and 3,971 food samples showed that the levels of decaBDE (BDE#209) were the highest among the congeners tested in almost all of the investigated food categories (EFSA, 2011). The concentration was highest in products of animal and vegetable fats and oils, and milk and dairy products (43.5% and 41.7%, respectively). The estimated mean chronic dietary exposure for average consumers to decaBDE was found to be between 0.35 and 2.82 ng/kg bw per day. The European Food Safety Authority (EFSA, 2011) estimates the average dietary exposure in Denmark to decaBDE (BDE#209) at 0.62-1.86 ng/kg b.w. per day.

2.3.2.6 Total human exposure in Denmark

The EFSA Panel on Contaminants in the Food Chain (CONTAM) concluded that for the general population, food is the main source of exposure to BFRs. The CONTAM panel further concluded that the current dietary exposure to decaBDE (BDE#209) is unlikely to raise a health concern (EFSA, 2011).

An exposure study of 2009 on pregnant women and their unborn children, which included measurement of PBDEs in house dust as well as in maternal and umbilical cord plasma, placental tissue, and breast milk from 51 pregnant women in the greater Copenhagen area, showed that the total internal exposure to PBDEs is of the same order of magnitude in Denmark as in other European countries, and of around one order of magnitude lower than in North America (Frederiksen *et al.*, 2010). BDE#209 (decaBDE) was measured in relatively high concentrations in both maternal plasma and placenta but could not be found in foetal plasma. However, the detection limit for BDE#209 is significantly higher than for the other congeners. Among all the matrices, the highest levels were found in the dust samples, where the dominant congener was BDE#209, which on average represented more than 90% of the total PBDE concentration. Correlation between the external exposure from the dust and the internal exposure, e.g. in the plasma or placenta, was most pronounced for the lower brominated congeners whereas the correlation for BDE#209 was generally low. This is probably due to the short half-life of BDE#209 in the body, which has been estimated at 14 days (23), combined with its physicochemical properties that limit the quantity absorbed and distribution in the body (Frederiksen *et al.*, 2010. However, a significant relationship was observed between BDE#209 in dust and maternal plasma, which may have occurred because these women had stayed primarily in their homes during the weeks up to the blood sample and thus had more even exposure in time up to sampling. The direct correlations between the levels of PBDEs in house dust and in various biological matrices indicated that house dust is a significant source of PBDE exposure in Denmark. Similar data have been reported by Vorkamp *et al.* (2011).

Biomonitoring data of Danish school children and mothers, including biomarkers of PBDE and glyphosate, have recently been published (Knudsen et. al., 2017). The study included seven PBDE congeners, but not BDE#209 (decaBDE).

2.3.2.7 Releases of decaBDE and presence in the environment

Information on decaBDE in treated sewage effluent and sewage sludge from public WWTPs is given above in the section on "DecaBDE in waste".

Few data on the presence of decaBDE and/or other PBDEs in environmental compartments in Denmark have been identified. DCE (2016b) compared results from their monitoring in three fish species (plaice, flounder and eelpout) under the NOVANA programme with existing EQS or EAC [11] values for PBDEs (sum of 6 PBDEs) in fish (0.0085 µg/kg ww). They found that at all seven locations where monitoring had taken place, the content of PBDE in fish tissue (muscle) exceeded the EAC values between 16 and 37 times.

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[11] EQS: Environmental Quality Standard, used in the EU; EAC: Environmental Assessment Criteria, used under OSPAR

The most commonly used PBDEs have been found in sediments, mussels, and fish in Denmark. A study from 2000 showed that the highest levels in sediments and mussels were found at stations near harbours and waste disposal sites, as illustrated in the figure below (from Lassen *et al.*, 2014b). As shown, DecaBDE was found to constitute a dominant part of the total content of PBDE in most of the samples.

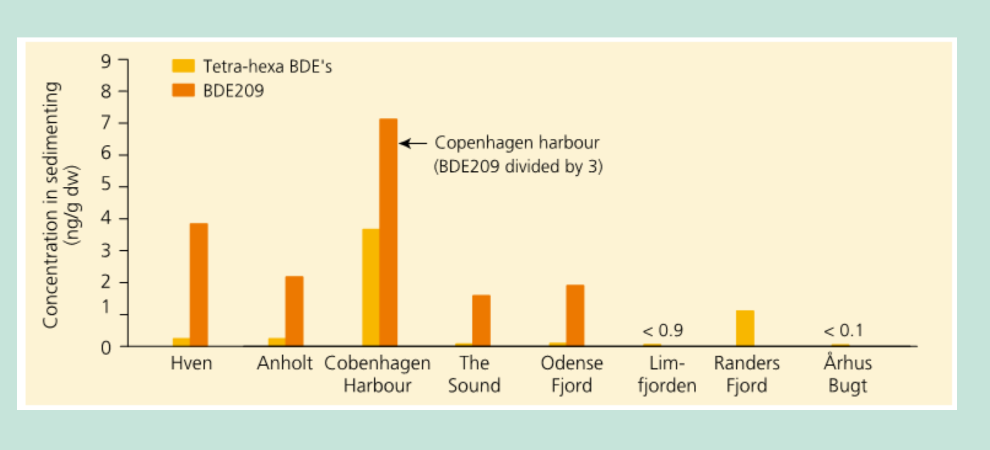

FIGURE 1. Concentrations of PBDEs in marine sediments in Denmark. BDE209 is decaBDE. (Dahllöf and Andersen, 2009)

According to HELCOM (2010, cfr. Lassen *et al.*, 2014b), PBDEs including decaBDE (BDE#209) mainly spread to the Baltic Sea environment through diffuse distribution via the atmosphere and rivers with the higher concentrations of brominated substances mainly distributed to the sediment and found only in low concentrations in fish. The observed levels in sediment are, however, generally below the PNEC (Predicted No-Effect Concentration) value. Few data are available for fish and these show, with one exception (median value of 47 µg/kg bw in roach from the Åland archipelago), low concentrations of the substance (few µg/kg bw).

2.3.3 Short-chain chlorinated paraffins (SCCPs)

A survey of short-chain (SCCPs) and medium-chain (MCCPs) chlorinated paraffins was undertaken as part of the Danish EPA's surveys of substances on the List of Undesirable Substances, LOUS (Lassen *et al.* 2014a). Based on the results of the survey, the Danish EPA developed a strategy for risk management of SCCPs and MCCP (Danish EPA, 2015c). The strategy listed three measures:

- Further information on exempted uses of SCCPs - Denmark awaits the results of an assessment undertaken by the European Commission
- Collection of information on SCCPs and MCCPs in building materials
- Further investigations of SCCPs in the Arctic environment.

2.3.3.1 Production of SCCPs in Denmark

There is no indication that SCCPs was ever manufactured in Denmark.

2.3.3.2 Current use and supply of SCCPs

No recent assessments of the consumption of SCCPs in Denmark are available (Lassen *et al.*, 2014a). According to data from the SPIN[12] database, the total registered consumption of SCCPs has been decreasing continuously from 23.5 tonnes in 2000 to 4.0 tonnes in 2011.

[12] SPIN - Substances in Preparations in the Nordic countries - is a database that contains "non-confidential" information on substances from the Product Registers of Norway, Sweden, Finland and Denmark. http://www.spin2000.euRAR

The SPIN database, as well as the Danish Product Register, only include mixtures for professional use, and it cannot be excluded that SCCPs was imported for consumer use.

According to data from the Danish Product Register generated for the purpose of this report, a total of 1.4-2.7 tonnes of SCCPs (CAS no 85535-84-8) was registered in 2016 in 10 products and reported by six companies. The application areas are confidential, but do not include the formerly exempted applications for conveyor belts in the mining industry and dam sealants. The total consumption in mixtures with < 1% SCCPs (exempted from the restriction) is 0.1 kg. The remaining part is comprised of mixtures with concentrations of > 1% SCCPs, which would be restricted today. The most likely explanation is that the data on the composition of the mixtures have not been updated by the registrants. Data on composition is often registered by foreign manufacturers of the mixtures, whereas information on the quantities of the mixtures placed on the market in Denmark or exported are reported by manufacturers or suppliers in Denmark. Information on quantities are updated more regularly than data on composition and it is common that it takes some years before changes in composition are reflected in the Product Register.

According to the LOUS survey for short-chain and medium-chain chlorinated paraffins (Lassen *et al.*, 2014a), there is no current, intentional use of SCCPs in Denmark for the exempted application as regards the mixtures confirmed by the current data from the Danish Product Register. SCCP may be present as impurity of mixtures with medium-chain chlorinated paraffins (MCCP). The total quantities of MCCPs in mixtures registered in the Danish Product Register in 2012 was 68 tonnes, and the main use categories were metalworking fluids, filling and padding materials and other uses which include primers and lubricants (Lassen *et al.*, 2014a).

With regard to SCCPs in articles, those with a content of SCCPs below 0.15% by weight are exempted from the restriction in the POP Regulation. Commission Regulation 2015/2030 notes that it is necessary to clarify that articles that contain SCCP in concentrations lower than 0,15 % by weight are allowed to be placed on the market and used, as this is the amount of SCCP that may be present as an impurity in an article produced with MCCP. No data are available on the possible import of articles with SCCPs to Denmark. The LOUS survey (Lassen *et al.*, 2014a) refers to an assessment of MCCPs in articles imported to Norway in 2009. In Norway the total import of MCCPs in articles was estimated at 205-409 t/y; of this 130-280 t/y MCCPs were in articles made of PVC and 34-101 t/y in articles made of rubber. The LOUS review suggests that the figures for Denmark are likely similar although the import in rubber may be lower.

The European Chemicals Agency's (ECHA) database on substances in articles includes two notifications[13]. The article categories are broad categories such as "Machinery, mechanical appliances, electrical/electronic articles" or "Plastic articles".

2.3.3.3 Historical use and supply of SCCPs in Denmark and the EU

SCCPs is registered by one company only in the EU. This company, based in the UK, had recently stopped its production of SCCPs when the LOUS survey was conducted (2014). The registered tonnage band for SCCPs at that time was 1,000-10,000 t/y. Today, SCCPs is registered in the tonnage band 1-10 t/y.

The estimated consumption of SCCPs in the EU in 2009 was about 530 tonnes, of which 45% was used in sealants and adhesives, 31% was used in rubber, 19% in paints and 6% in textiles. Until 2000, the main use of SCCPs was in metal working fluids but this practice was

[13] https://echa.europa.eu/documents/10162/c6fe097d-2785-4121-a6d8-fcd237609221

banned in 2004 (Lassen *et al.*, 2014a). Around 1990, about 15% of the European consumption of chlorinated paraffins was SCCPs.

Historical, significant uses of SCCPs are the following (Lassen *et al.*, 2014a):

- Sealants and adhesives: Main use in sealants rather than adhesives, primarily for filling of expansion and movement joints in building and general engineering, joints for protection from spillages and where resistance to water and chemicals etc. is required, and waterproofing of roofs.
- Paints: Chloro-rubber and acrylic protective as well as intumescent paints, with road marking paints being a key application, but also e.g. anticorrosive coatings and swimming pool coatings.
- Rubber: Conveyor belts for underground mining and to a minor extent other rubber products.
- Textiles: Furniture upholstery, seating upholstery in transport applications, interior textiles such as blinds and curtains, and tents and protective clothing.

In Denmark, SCCPs were used in sealants and other building materials until 2002 (Odsbjerg *et al.*, 2016).

2.3.3.4 SCCPs in waste

Solid waste. Materials in which SCCPs have been used intentionally typically contain more than 1% (10.000 kg/kg) of SCCPs and are therefore classified as hazardous waste according to the Danish statutory order on waste due to the harmonised classification as Carc. 2. The main materials with contents of SCCPs accumulated and present in society are sealants and adhesives, rubber, paints and textiles, but quantitative data on the content of SCCPs in these waste materials have not been identified.

In the LOUS survey, Lassen *et al.* (2014a) estimated the following approximate tonnages for SCCPs-containing wastes in Denmark. The estimates were extrapolations of data for the entire EU (ESWI, 2011).

TABLE 11. Disposal of SCCPs in post-consumer waste in Denmark in 2014 (Lassen *et al.*, 2014a)

Product group	Concentration in materials	Potential quantities of SCCPs, t/y *2	Disposal method in Denmark
Rubber – mainly gaskets and hoses	10-17 %	1.1 *1	Landfill as waste from shredders: Rubber in vehicles (may be incinerated in the future) Incineration: Other applications
Sealants and adhesives	10-20 %	2.5	Incineration: Sealants and adhesives attached to combustible waste Material recovery if not segregated from demolition waste (adhesives and sealants on concrete and tile) Hazardous waste incineration: Materials identified as part of the management of double-glazed windows, demolition and renovation of buildings
Paints	1-20 %	2.9	Incineration: Paints on combustible materials Metal recycling: Paints on metal surfaces Material recovery if not segregated from demolition waste: Paints on concrete and tile
Textile *4	20 %	0.2	Landfill as waste from shredders: Textile in vehicles (may be incinerated in the future) Incineration
Leather	2 %	0	Incineration
Total		6.6	

*1 Calculated from the EU figures for gaskets and hoses. SCCPs-containing conveyer belts for mining operations are not used in Denmark.

*2 Extrapolated from ESWI (2011) assuming that the historic consumption in Denmark has been similar to the rest of the EU and that Denmark represents 1% of the total EU consumption (based on population size).

*3 36% of SCCPs is used for packaging, 36% for other products and the remaining for wood working, transportation and consumer goods.

*4 Typical applications potentially included furniture upholstery, seating upholstery in transport applications, and interior textiles such as blinds and curtains, as well as industrial protective clothing.

SCCPs in building materials. Odsbjerg *et al.* (2016) analysed a substantial number of data from a total of 502 reports on refurbishment and/or demolition projects for Danish buildings. Two hundred and twenty-two of these reports include data on chlorinated paraffins (SCCPs and MCCPs) in building components, comprising a total of 3,430 samples of different materials. First, a screening level analysis was carried out, after which the samples where the screening indicated content of chlorinated paraffins were subjected to a specific analysis for CPs. In total, 747 specific analyses (225 of the total number of samples taken) were carried out, of which 23% (174) were shown to contain chlorinated paraffins. The results of the specific analyses are shown in the table below. As can be seen from the figures in the table, sealants were the material with the highest frequency of detection of both SCCPs and MCCPs.

Of the 170 samples with SCCPs, 55 had concentrations in the 100-9,900 mg /kg range, 55 contained 10,000-49,900 mg/kg, 29 samples contained 50,000-99,900 mg/kg, and 31 had concentrations at or above 100,000 mg/kg. Therefore, 68% of the samples had concentrations which rendered the materials hazardous waste. One sample of paint and one of adhesive for flooring contained more than 10,000 mg/kg.

Odsbjerg *et al.* (2016) concluded on the basis of the investigation that it was not possible to estimate the total quantities of building waste with SCCPs.

TABLE 12. SCCPs and MCCPs found in building materials in Denmark (Odsbjerg *el al.*, 2016). The percentages indicated the percentage of the total number of samples for each type of materiel containing SCCPs or MCCPs, respectively. Some of the samples contained both types.

Material	Total number of analyses	Number with SCCPs	Number with MCCPs
Sealants	563	162 (29%)	113 (20%)
Paint	132	3 (2%)	2 (2%)
Flooring	27	2 (7%)	0 (0%)
Adhesive for flooring	15	3 (25%)	1 (7%)
Floor lacquer	3	0	0
Other materials	3	No data	No data
All materials	743	573 (77%)	170 (23%)

Waste with SCCPs concentrations above 10,000 mg/kg is classified as hazardous waste. Materials with SCCPs above 10,000 mg/kg (1%) are disposed of to undergo hazardous waste incineration. Materials with lower concentrations may be disposed of in MSW incinerators. In comparison, the limit value for PCB (as in building materials, PCB is included in concentrations of the same magnitude as SCCPs) is 50 mg/kg. The concentration of the two substances in the sealants is similar. The low limit of PCB compared with the concentration of PCB in the building materials means that the concentration in surrounding materials, such as concrete or brick, is higher than the limit value often due to migration (secondary contamination) and must be removed selectively and disposed of as hazardous waste. Some SCCPs may migrate to surrounding materials, but no data on SCCPs in surrounding materials have been identified. For PCB it is known that concentration in surrounding materials may be above 10,000 mg/kg, particularly in polymeric materials. Odsbjerg *et al.* (2016) estimate that the concentration of SCCPs in surrounding materials would only seldom be more than 10,000 mg/kg, so usually only the SCCPs-containing material in itself needs to be selectively handled. Total quantities of SCCPs-containing building waste would, consequently, be much lower than the quantities of PCB-containing waste.

Fate by incineration. According to ESWI (2011), it is assumed that SCCPs decompose at about 200°C and that, at an incineration temperature of at least 850°C, complete destruction of SCCPs is expected. Therefore, SCCPs would be degraded under the temperatures and conditions that prevail in Danish MSW incineration plants. The actual destruction efficiency for SCCPS in Danish incineration plants is currently under evaluation in an assessment for the Danish EPA.

Wastewater. In connection with a larger study on environmental contaminants in the Baltic Sea (the COHIBA project), Nielsen *et al.* (2012) examined releases of a number of contaminants including SCCPs+MCCPs from various types of sources to Copenhagen Harbour and the Sound (Øresund). The sources included the outlets of treated sewage effluent from two major WWTPs in Copenhagen (Lynetten and Damhusåen) and by-pass outlets (untreated sewage) for the same two WWTPs as well as the overflow from a combined sewer system in the catchment.

TABLE 13. Sum of SCCPs and MCCPs in sewage and treated sewage effluent from two major WWTPs in Copenhagen (from Nielsen *et al.*, 2012).

Source	Treated effluent (µg/L)	Untreated sewage * (µg/L)
WWTP 1	0.021	0.088
WWTP 2	0.033	0.15
Combined sewer overflow	-	0.383

* By-pass or overflow

No Danish data on the content of SCCPs in sewage sludge has been identified; however, the vast majority of SCCPs in sewage/wastewater would be expected to be distributed to the solid phase (sludge) in a WWTP due to its physico-chemical properties (sorptivity).

Sewage sludge. No Danish data on the content of SCCPs in sewage sludge and no risk evaluations have been identified. Swedish investigations into two WWTPs found levels of SCCPs ranging from 0.16 to 0.87 mg/kg dw (Wahlberg, 2016). The levels in the sludge were well below the suggested Swedish limit values for SCCPs in sludge (the limit values not indicated in the report) (Wahlberg, 2016).

2.3.3.5 SCCPs in indoor air

No data on SCCPs in indoor air in Denmark have been identified.

A Swedish study found a mean concentration of the sum of SCCPs and MCCPs in 40 out of 44 indoor air samples at 69 ng/m³ (median 64 ng/m³, range <5-212 ng/m³) (Fridén *et al.*, 2010).

The LOUS Survey (Lassen *et al.*, 2014a) reviewed data from other countries and discussed to what extent SCCPs in the indoor air would be of concern. SCCPs has been used for some of the same applications in buildings as PCBs or have actually substituted for PCB in many applications. For PCBs in the indoor climate, two action levels of 300 and 3,000 ng/m³ have been recommended by the Danish Health Authority. The action levels are based on similar levels established in Germany and based on a tolerable daily intake (TDI) of 1 - 3 µg PCB/kg bw/day (Jensen, 2013). A TDI of 100 µg/kg bw/day for non-neoplastic effects of SCCPs for the general population was derived by the International Programme on Chemical Safety (IPCS, 1996 as cited by Lassen *et al.* (2014a), meaning that the TDI for SCCPs is 10-100 times the TDI for PCB.

The levels of SCCPs in the indoor air, when considering the actions levels for PCB, and the differences in TDI between SCCPs and PCB, indicate that SCCPs in the indoor environment would not be of major concern.

2.3.3.6 SCCPs in food and drinking water

No specific data on the presence of SCCPs in food and drinking water in Denmark have been identified.

2.3.3.7 Total human exposure in Denmark

In the EU Risk Assessment Report for SCCPs from 2008 (EC, 2008b), no health risks from the exposure to SCCPs were identified for consumers and the general population, i.e. the exposure level was found to be well below the TDI of 100 µg/kg bw/day. A reasonable worst-case scenario of SCCPs intake via the environment of 20 µg/kg bw/day was suggested. However, due to the reduced emissions resulting from more recent restrictions on the use of the SCCPs, this estimate is regarded as outdated (too high).

It is likely that intake of SCCPs via food contributes more to total human exposure than intake via air and dust. Based on biomonitoring data, especially Swedish data on SCCPs in breast milk in the period from 1996-2010 where the average content was 107 ng SCCP/g fat, the overall exposure levels do not appear to have changed significantly in recent years (Lassen *et al.*, 2014a).

2.3.3.8 Releases of SCCPs and presence in the environment

Releases of SCCPs to the environment via sewage effluent, sewage sludge and emissions from MSW incineration plants are described above in the section on waste.

SCCPs as a group is not included in the national Danish environment and nature surveillance programme, NOVANA; hence, very few data on the presence of this group of chemical substances in the environment in Denmark are available.

However, a screening of SCCPs and MCCPs in Danish marine and freshwater sediments was conducted in 2008 (Larsen *et al.*, 2010) and the results (average concentrations found) are summarised in TABLE 14. MCCPs were not detected in the samples.

TABLE 14. SCCPs in marine and freshwater sediments in Denmark. Results of a screening conducted in 2008 (Larsen *et al.*, 2010)

Sediment type	Number of samples	Average concentration ± SD (µg/kg)
Marine sediments	10	25 ± 7
Fresh water sediments	10	27 ± 11

As part of the COHIBA project ("Control of Hazardous Substances in the Baltic Sea Region"), Nielsen *et al.* (2012) reported results from analyses of a number of environmental samples taken in the Copenhagen region including the Sound (Øresund) and the western Baltic Sea. The analyses included the sum of SCCPs and MCCPs. In a marine water sample from the Sound, the sum concentration was 0.28 µg/L while in the western Baltic Sea the level was 0.16 µg/L. In a stream southwest of Copenhagen, Harrestrup Å, a sum level of about 0.2 µg/L was observed. According to the final report of the COHIBA project (COHIBA, 2012), MCCPs accounted for a dominant part of the sum of chlorinated paraffins found in the Baltic Sea environment.

The German Federal Environment Agency has published data on fish liver and sediment concentrations of chlorinated paraffins in the North and Baltic seas (UBA, 2008). The average fish liver concentrations in samples of cod, dab and flounder from the North Sea was 144 ng/g ww, as compared to 19 ng/g ww in the Baltic Sea samples. IVL (2009) found an average of 23 ng/g ww in fish livers from the Baltic Sea.

2.3.4 Pentachlorophenol (PCP) and its salts and esters

2.3.4.1 Production of PCP in Denmark

According to available information, pentachlorophenol (PCP) has never been produced in Denmark but has previously been imported to and used in the country, primarily as a wood preservative.

2.3.4.2 Current use and supply of PCP

There is no known current use and supply of PCP as the marketing and use of the substance has been banned in the EU since 1991 (Council Directive 76/69/1991) and has been included in Annex XVII under REACH (by Commission Regulation 552/2009) since 2009. In theory, it may still be present as an impurity in other chemicals or mixtures in concentrations lower than 0.1%.

2.3.4.3 Historical use and supply of PCP in Denmark and the EU

Historically, the main use of PCP in Denmark has been as a wood preservative. According to Danish statistics on sale of pesticides (Kemikaliekontrollen, 1981), the last recorded sale was in 1979, where 11 kg (amount active substance) was sold. At that time, certain biocidal uses of PCP such as preservation of wood still occurred. However, throughout the 1970s, the typical annual sale of PCP in Denmark was in the range of 1,000-1,500 kg/year (Kemikaliekontrollen, 1975, 1978 and 1981).

In addition to wood preserved with PCP in Denmark, the substance also occurred in imported, preserved wood. In a survey of the use of chlorophenols in Denmark, COWIconsult (1985) estimated the amount of PCP in imported wood at 1-6 t/year in 1983. The authors particularly mention frames for cultivation of mushroom as an application where PCP was much used but with a strongly decreasing trend from 1983 to 1984 (from 3 tonnes to 0.7 tonnes).

Further, COWIconsult (1985) indicate use of PCP for preservation of leather (1-11 t/year) and preservation of textiles for outdoor use, e.g. tents (cotton; 2-9 t/year). They also mention mixing of PCP into mortar for use in joints around old wood constructions. The total use of PCP in 1983 was estimated at 7-30 t/year. The use for preservation of leather was stopped per 1 January 1985.

The report does not indicate any use of PCP for production of railway sleepers or power poles or any import of PCP with these products. In Denmark these products have mainly been preserved with creosote. Hansen and Hansen (2004) do neither indicate any use for railway sleepers or power poles, but state that PCP was mainly used for surface impregnation and priming of wood and preservation of wooden windows and doors.

The use of PCP has been banned in Denmark since 1996 when the Statutory Order on marketing and use of PCP (Statutory Order No. 420 of 21/04/1996) entered into force. This Statutory Order was replaced in 2009 by Statutory Order No. 854 of 05/09/2009 supplementing EU Regulation No. 552/2009.

The import of PCP in treated wood was surveyed in an unpublished report for the Danish EPA (Lassen, 2000, as cited by Hansen and Hansen, 2004). According to an update by Hansen and Hansen (2004), no traces of PCP were found in analyses in 2003 of imported tropical wood. However, it was considered that at the time of the survey, small amounts of PCP-treated wood could possibly still enter Denmark as a result of imports of tropical wood from Africa and Asia.

As part of their study, Hansen and Hansen (2004) analysed samples of transport pallets from France, Spain and Portugal for content of PCP and detected the substance in 6 out of 10 samples at levels ranging from 21 to 231 µg/kg.

2.3.4.4 PCP as a source of formation of dioxins

It is well established that technical PCP contains a number of impurities (the purity of the technical product is typically 90% or lower), among them polychlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs), which are generated during the PCP production process. PCP is also known to be a precursor of the formation of PCDDs and PCDFs during combustion processes e.g. at municipal and hazardous waste incineration plants or by uncontrolled burning of preserved wood (mainly the higher chlorinated dioxins and furans). The first Danish Statutory Order on PCP of 1977 concerned restrictions on dioxins in PCP (Statutory Order 582 of 28/11/1977).

PCP-treated wood was identified as a possibly substantial source of the Danish dioxin emission in the two Substance Flow Analyses from 2000 and 2003. A project was therefore initiated with the aim to get a confirmation of whether PCP-treated wood should be regarded as a substantial source of dioxin in Denmark by evaporation of dioxin from the wood (Hansen and Hansen, 2004). The study estimated the remaining amount of dioxin in Danish PCP-treated construction wood at 42 - 974 g I-TEQ. As part of the study, dioxins were analysed in an imported pallet with a content of PCP of 231 µg/kg. The dioxins concentration was 4.6 ng WHO-TEQ/g. The total emission from PCP-treated wood was estimated at 0.23 - 9.9 g I-TEQ/year, which confirmed that PCP-treated wood at that time accounted for a significant contribution to the total dioxin emission in Denmark.

2.3.4.5 PCP in waste

Solid waste. According to its uses, PCP would be expected to occur as waste mainly in old impregnated wood and impregnated leather and outdoor textiles. The use of PCP as wood preservative ceased in 1979, about 40 years ago. Furthermore, as a result of use restrictions and a ban in 1996 on sale, import and export of goods containing more than 5 mg/kg PCP, the use of the substance in other applications of Denmark actually ceased about 20 years ago and not much PCP would be expected to be present in the waste that is currently being generated. Presumably, most of the old waste containing PCP has been disposed of.

The amount of PCP-treated wood still in use in Denmark in 2000 was assumed to correspond to an initial PCP quantity of approximately 680 tonnes, while the estimate for 2003 is assumed to correspond to an initial PCP-quantity of 430 tonnes (Hansen and Hansen, 2004).

According to ESWI (2011), the amounts of PCP in PCP-containing waste for disposal in the EU is rapidly declining from more than 6,045 tonnes in 2010 to 766 tonnes in 2018; the number is expected to be less than 401 tonnes by 2021 and reach negligible levels (less than 10 tonnes) by 2030. It should be noted that in some EU Member States, an exemption to the general ban on use of PCP was in force until the end of 2008 (ESWI, 2011).

As part of the stakeholder consultation, one of the questions addressed the extent to which extent power poles stored in some landfills could contain PCP. Considering that the surveys from 1985 and 2004 did not indicate any use of PCP for power poles, storage in power poles was not further investigated.

Fate by incineration. According to ESWI (2011), PCP is largely destroyed during incineration in MSW incinerators. An assessment of the destruction of PCP in incinerators included neither an ongoing Danish assessment of destruction efficiencies for the Danish EPA nor a recent Swedish assessment (Lundin and Jansson, 2017).

Waste water. DMU (2006) summarised monitoring studies of several pollutants in sources of aquatic pollution, including pentachlorophenol. The mean concentration of PCP in treated WWTP effluent from the period 1998-2003 was 0.01 µg/L; the substance was found in 18 out 150 samples. The total annual release of PCP from Danish WWTPs in the period 1998-2003 was estimated at 4.7 kg/year.

Sewage sludge. The average content of PCP in sewage sludge from the same period was 0.026 mg/kg dw (PCP was found in 27 out of 30 samples). No risk evaluation of PCP in sewage sludge in Denmark is available.

2.3.4.6 PCP in food and drinking water

Pentachlorophenol has previously been included in the Danish monitoring programme for contaminants in food. PCP has not been observed in any categories of food since the publishing of monitoring results began in 1999. The substance is not part of the monitoring process at present.

In 2003, the daily intake of PCP with food was estimated to 0.1-6 µg/person/day by the Danish Food Directorate (Fødevaredirektoratet, 2003). The Directorate concluded that the intake with fish was considerably lower than the TDI for PCP and, hence, the Directorate found no reason for concern with regard to impact of PCP due to intake of fish.

The Danish limit value for PCP in drinking water is 0.01 µg/L; the substance has been monitored for many years as part of the Danish groundwater surveillance programme, GRUMO. In the period 2011-2014, PCP analyses were carried out on a total of 815 groundwater samples. With a detection limit of 0.01 µg/L, PCP could not be detected in any of the analysed samples (GEUS, 2015). In the monitoring period 1993-2002, PCP was detected in seven out of 2101 samples (0.3%) of water from abstraction wells from Danish waterworks. The median level in the samples where PCP was detected was 0.08 µg/L (GEUS, 2003).

2.3.4.7 Total human exposure in Denmark

The total human exposure to PCP in Denmark at present is considered to be negligible. No Danish biomonitoring data have been identified. In Germany biomonitoring data indicates a decrease in exposure (Allum, 2018)

2.3.4.8 Releases of PCP and presence in the environment

DMU (2006) summarised monitoring studies of various sources of aquatic pollutants, including pentachlorophenol. The mean concentration of PCP in treated WWTP effluent from the period 1998-2003 was 0.01 µg/L and the substance was found in 18 out 150 samples. The average content of PCP in sewage sludge from the same period was 26 µg/kg dw (PCP was found in 27 out of 30 samples). The total annual release of PCP from Danish WWTPs in the period 1998-2003 was estimated at 4.7 kg/year.

No recent data on the occurrence of the substance in soil, water or biota in Denmark have been identified. Based on groundwater monitoring (GRUMO) data for the period 1998-2003, DMU (2006) reports a median concentration in primary groundwater reservoirs of about 0.04 µg/L with a maximum of 0.12 µg/L. Levels found by Geological Survey of Denmark and Greenland (GEUS) in ground- and drinking water in the periods 1993-2003 and 2011-2014, respectively, are described above in the section on food and drinking water.

In the NOVA 1998-2003 programme for surface water, PCP was not detected in four out of five rivers/streams, but found only in one stream generally affected by urban contamination at concentrations ranging from 0.02 to 0.57 µg/L. The substance was not detected in any of the analysed marine samples (DMU, 2006).

In the same report (DMU, 2006), the mean concentration of PCP in sewage sludge from municipal WWTPs in 1998-2003 was 26 µg/kg dry matter while the 95^{th} percentile concentration was 116 µg/kg dm. The soil quality criterion of PCP is 0.15 mg/kg soil (150 µg/kg soil) (Danish EPA, 2018).

2.3.5 Polychlorinated naphthalenes (PCNs)

2.3.5.1 Production of polychlorinated naphthalenes in Denmark

There is no indication that PCNs have ever been manufactured in Denmark.

2.3.5.2 Current use and supply of polychlorinated naphthalenes

Intentional use of PCNs was phased out globally several years ago and, hence, despite lack of concrete information on this topic, there is no reason to believe that there are any current intentional uses or supply of PCNs in Denmark.

However, it seems to be well established (e.g. Jakobsson and Asplund, 2008; Liu *et al.*, 2014) that PCNs are formed unintentionally as by-products in thermal processes where chlorine is present. Some of these processes are also potentially relevant in a Danish context, e.g. MSW incineration, medical waste incineration, domestic wood burning and secondary aluminium smelting. According to Santillo and Johnston (2004), the developing consensus is that PCNs are predominantly formed through post-combustion chlorination of naphthalene and other PAHs, especially on the active surfaces of fly ash particles. Thus, formation of PCNs may also take place at present in Denmark.

2.3.5.3 Historical use and supply of polychlorinated naphthalenes in Denmark and the EU

No information on historical uses and supply of PCNs in Denmark has been identified, but as PCNs have had some of the same uses as PCB, it cannot be completely excluded that import and use of these substances has taken place to some (limited) extent. Such theoretical uses are believed to have been discontinued not later than the time that PCB was banned.

The most important uses of PCNs, in terms of volume (worldwide), have been for cable insulation, wood preservation, engine oil additives, electroplating masking compounds, feedstocks for dye production, dye carriers, capacitors and refracting index testing oils (van der Plassche and Schwegler, 2002).

According to van der Plassche and Schwegler (2002), most of the global production of PCNs took place from the 1920s to the 1950s, with the majority occurring in the USA. The worldwide production in the 1920s has been estimated at about 9,000 t/year. Thereafter, the production volume gradually decreased until coming to an end globally before the end of the 1980s. The total, global production volume of PCNs has been estimated at about 150,000 tonnes, based on the assumption that the production volume of PCNs was about 10% of the PCB production volume.

In the USA, most of the production of PCNs ceased in 1977 and all production had ceased by 1980. In Europe, some production in Germany and the UK (main producers Bayer and ICI) still took place in the early 1980s (100-300 t/y) but apparently ceased in 1984. However, minor uses of PCNs in Germany taking place until 1989 have been reported (WHO, 2001).

There may still be some limited amount of PCNs in circulation in Denmark, as PCNs have been shown to occur as impurities in technical PCB at the ppm-level. This situation will be managed along with PCB. To illustrate this, Falandysz (1998 cfr. van der Plassche and Schwegler, 2002) found a median level of 67 mg/kg in commercial PCB mixtures such as Aroclor and Clophen and a maximum content of 870 mg/kg in the investigated samples.

2.3.5.4 Polychlorinated naphthalenes in waste

Solid waste. No figures on the occurrence of PCNs in Danish waste have been identified. However, ESWI (2011) has made estimates for PCNs in some waste streams in the EU27 based on national waste volumes and generic emission factors for PCNs in various processes.

Sewage sludge. For sewage sludge ESWI (2011) did not make any estimate for Denmark due to missing data on sludge volumes. However, according to "Waste Statistics 2015" from the Danish EPA (2017), the volume of sewage sludge has been rather stable over the period

2008-2015, about 130,000 t/year. If the emission factor used by ESWI (2011) for Sweden of 4.5 ng PCN/g sludge (which is considerably lower than the EU average of about 40 ng/g but believed to be more representative) is also used for Denmark, the amount of PCNs in Danish sewage sludge are estimated to be about 0.6 kg/year. About 25% of sewage sludge in Denmark is incinerated while more than 60% is applied to agricultural soil. No risk evaluation of PCNs in sewage sludge in Denmark is available.

2.3.5.5 Polychlorinated naphthalenes in food and drinking water

No data on the possible content of PCNs in food and drinking water in Denmark have been identified. The website of the Danish Veterinary and Food Administration, the national authority responsible for monitoring and control of contaminants in food on the Danish market, has no information indicating that PCNs should ever have been monitored/identified in any category of food in Denmark. PCNs are not included in the national monitoring programmes for groundwater and drinking water in Denmark and no limit value has been established for these substances in drinking water.

However, the Food Safety Authority of Ireland (FSAI) carried out a study in 2007-2008 (FSAI, 2010) on the levels of PCNs in carcass fat, liver, eggs, fish and milk produced in Ireland and a number of processed products available at the retail level. The study concluded that as the PCNs congener profile found is similar to that of commercial mixtures, the pattern of PCNs in food in Ireland reflects the past commercial uses of this substance group more so than the reported unintentional sources of exposure (waste incineration etc.). Overall, the FSAI finds the levels of PCNs to be low and not worthy of concern for human health.

The sums of nine measured PCNs congeners in products of vegetable origin were in all cases (except in cabbage due to one congener (53)) below 1 ng/kg fresh weight, corresponding to dioxin (2,3,7,8-TCDD) TEQ-levels of less than 0.001 ng/kg fresh weight. The levels in animal products, in particular fish and especially farmed salmon, were somewhat higher, typically with a ΣPCNs of a few ng/kg fresh weight and a maximum of 43 ng/g (mean value) in farmed salmon. With the exception of farmed salmon, the corresponding dioxin TEQ-levels for all animal products (mean values) were below 0.01 ng/g (the level in salmon was 0.022 ng/g) (FSAI, 2010).

2.3.5.6 Total human exposure in Denmark

In the absence of specific information on the subject, it is assumed that the character of human exposure to PCNs in Denmark resembles that of PCB, which is dominated by exposure due to intake via food. However, the exposure to PCNs occurs at a much lower level. It seems likely, based on the information on PCBs and the results of the above Irish study by FSAI (2010), that the exposure is due to the use of products containing PCNs rather than exposure from sources of unintentional generation of PCNs.

It is likely that the use of PCNs in Denmark has been quite limited and it may well be that a substantial part of current human exposure originates from PCNs impurities in PCB products, which were determined in 18 commercial PCB mixtures by Yamashita *et al.* (2000), who found the content of PCNs to vary from 5.2 to 730 mg/kg PCB product. This range is well in line with the median value of PCNs in PCB mixtures of 0.0067% (≈ 67 mg/kg) reported by Falandysz (1998) (cfr. van der Plassche and Schwegler, 2002).

2.3.5.7 Releases of polychlorinated naphthalenes and presence in the environment

PCNs can be released to the environment from past uses of PCNs, from impurities in PCB products and as a result of unintentional generation in thermal processes, including MSW incineration.

Based on Eurostat data for Denmark (2008 figures), the following PCNs emissions from incineration of municipal solid waste (MSW) and incineration of hospital waste were estimated by ESWI (2011) (TABLE 15).

TABLE 15. Estimated emissions of PCNs in Denmark (2008) from incineration of municipal solid waste (MSW) and hospital waste (ESWI, 2011)

Waste type	Volume incinerated (t/year)	PCNs emitted through fly ash (kg/y)	PCNs emitted through bottom ash (kg/y)	PCNs emitted as off-gas (kg/y)
Municipal solid waste	2,400,000	1.06	0.72	0.20
Hospital waste	1,748	0.21	0.52	0.47

For domestic burning of wood in Denmark, an amount of 920,000 t/year has been used to calculate an annual emission of PCNs to air of 0.023 kg/year and a discharge to ash of 0.12 kg/year (ESWI, 2011).

For the limited production of secondary aluminium in Denmark of 14,000 t/year, PCNs emission to air was calculated as 0.010 kg/year as well as filter dust amounts of 0.011 kg/year.

Thus, the total emission of PCNs in Denmark from waste-related sources amounts to approximately 3.9 kg/year.

However, no data on occurrence and levels of PCNs in the Danish environment have been identified with the exception of some data on biota in Greenland and the Faroe Islands monitored under the AMAP programme.

The review by van der Plassche and Schwegler (2002) mentions a study by Järnberg *et al.* (1997) of PCNs in Swedish lake sediments. The background level was found to be 0.23 ng/g dw while in other sediments the levels varied from 0.62 to 270 ng/g dw, with the highest levels in PCB polluted areas and near chlor-alkali industry sources. In an Italian study from 1999, a background concentration in lake sediment of 0.034 ng/g dw and a concentration of 1.5 ng/g dw in lake sediments downstream from a WWTP using chlorine were found.

In a British study (referred to by van der Plassche and Schwegler, 2002) where soil archive samples from the period 1944 to 1986 were analysed, the ΣPCNs concentration was found to be 6.0 µg/g in 1944 and 317 pg/g (≈ 0,00032 µg/g) in 1986. In soil from another location where sewage sludge had been amended, the sludge amendment resulted in a four-fold increase in the PCNs level compared to the untreated control.

Fish (unspecified species) from the Baltic Sea were found to contain PCNs in the range from 0.98-26 ng/g (lipid weight basis) in a study by Järnberg *et al.,* 1997; referred to by van der Plassche and Schwegler, 2002), while the content in birds (guillemot and white-tailed sea eagle) was somewhat higher (84-220 ng/g and 120-130 ng/g (lipid weight), respectively). Falandysz *et al.* (1996) report 8.9-290 ng/g (lipid weight) in herring from the Baltic Sea.

Rotander *et al.* (2012) reported levels of PCNs in a number of whale and seal species based on samples taken in the Arctic and North Atlantic area in the period 1986-2009. The levels (sum of five PCNs congeners) vary from 0.03 to 5.9 ng/g lipid weight (blubber samples). It was found that PCNs accounted for less than 0.2% of the content of non-planar PCBs and, with one exception, the lowest levels were found in samples from the most recent sampling period.

2.3.6 Hexabromocyclododecane (HBCDD)

A survey of HBCDD and other brominated flame retardants was undertaken as part of the Danish EPA's surveys of substances on the List of Undesirable Substances, LOUS (Lassen *et al.* 2014b). Based on the results of the survey, the Danish EPA developed a strategy for risk management of brominated flame retardants (Danish EPA, 2014). The strategy listed a number of measures mainly focused on unrestricted brominated flame retardants. Some measures addressing alternative methods for obtaining fire protection without the use of halogenated flame retardants may be relevant to HBCDD.

2.3.6.1 Production of HBCDD in Denmark

There is no indication that HBCDD has ever been manufactured in Denmark.

2.3.6.2 Current use and supply of HBCDD

HBCDD was included in the LOUS review of brominated flame retardants (Lassen *et al.*, 2014); at the time of that review (statistical data from 2012), the total consumption of HBCDD for production purposes in Denmark was about 1 tonne as compared to 6-13 tonnes in 1999. The main use of HBCDD in Denmark was for manufacture of EPS sheets for building/construction applications and packaging for electronics.

According to the Nordic SPIN Database (accessed August 2018), there has been no consumption of preparations for professional use containing HBCDD in Denmark since 2000. Data from the Danish Product Register obtained for the purpose of this report do not reveal any current consumption in Denmark of preparations for professional use containing HBCDD.

In the EU, the average consumption of HBCDD for the period 2010-2011 was 10,000-12,500 t/y and HBCDD was the BFR used in the highest quantities in the EU at that time.

By Regulation (EU) 2016/293, the EU has put restrictions on the future use of HBCDD; however, there is an important exemption for the use of expanded polystyrene (EPS) in buildings lasting until 6 months after the general expiry date of the exemption for EPS (26 November 2019). Other uses of HBCDD are already banned and only occur as unintended contaminants in other substances. Preparations or articles at levels equal to or less than 100 mg/kg (0.01%) are exempted from the ban.

According to the European Manufacturers Association of Expanded Polystyrene EUMEPS, flame retarded EPS containing HBCDD is no longer supplied on the European market, even though an authorization under REACH was granted in 2016 to a consortium of companies for two HBCDD uses in EPS for building applications. However, by the time authorization was granted, alternative flame retardants were already available, and therefore the companies decided to withdraw from the authorization (EUMEPS, 2016).

In conclusion, it is considered likely that the use of HBCDD in Denmark and the EU at the time of writing has ceased and largely been replaced by other flame retardants in EPS for building applications where flame retardancy is still required.

2.3.6.3 Historical use and supply of HBCDD in Denmark and the EU

According to a substance flow analysis for brominated flame retardants (Lassen *et al.*, 1999), the consumption of HBCDD in Denmark for production purposes was 6-13 tonnes in 1999, of which a considerable fraction was exported. In 1999, the main consumption of HBCDD in Denmark was in building/construction materials (EPS/XPS) and textiles for furniture was in imported flame retarded extruded polystyrene (XPS), accounting for 11-29 tonnes HBCDD.

The consumption of HBCDD in 1999 was estimated at a total of 26-80 t/year with the following distribution:

- HIPS (high-impact polystyrene) used in wiring of houses: 2-4 t/year
- Textiles, carpets and furniture: 2-9 t/year
- Transportation (mainly textiles): 9.4-30 t/year
- Extruded polystyrene foam (XPS) used in construction: 11-29 t/year
- Expanded polystyrene foam (EPS) used in construction: 1.5-6.7 t/year.

In 2012 the total consumption for production in Denmark had decreased to about 1 t/y (Lassen *et al.*, 2014b). The LOUS review did not estimate total import in articles, but noted that the substances' (EPS and XPS) presence in building materials had likely not changed since 1999. XPS imported from places other than the Nordic countries would include HBCDD. It further notes that the consumption of flame-retarded EPS in Denmark appears to be increasing in "zero energy" houses of a new construction, wherein the walls are built of flame-retardant EPS blocks covered with a non-combustible material. The flame retarded EPS used for this purpose was imported.

With a total consumption of HBCDD in EPS/XPS of approximately 20 t/year in 1999, the consumption in Denmark for building materials was well below the EU average.

The total volume used in the EU was estimated to amount to about 8,900 t/year in 1999 and 11,580 t in 2006 (ESWI, 2011). If the per capita consumption in Denmark were the same as the EU average, the consumption would be around 100 t/year. The main difference is in the use of flame retarded EPS/XPS in building and construction. This difference is partly due to more limited use of EPS/XPS in buildings and the fact that the majority of the EPS used is not flame retarded. In other countries, such as Germany and Poland, all EPS/XPS used in building and construction is flame retarded.

Globally, the consumption of HBCDD increased from 16,700 t/y in 2001 to 31,000 t/y in 2011 (Lassen *et al.*, 2014b). In 2009, about 70-90% of HBCDD consumed in the EU was estimated to be used in EPS/XPS for building insulation materials, less than 10% in plastic parts (HIPS) for electronics and 2% in flame retarded textiles (UBA, 2013).

2.3.6.4 HBCDD in waste

Solid waste. No specific data on the presence and levels of HBCDD in different categories of waste in Denmark have been identified. The LOUS review report (Lassen *et al.*, 2014b) does not contain quantitative information on HBCDD in waste.

The main types of waste in Denmark containing HBCDD are flame-retarded EPS/XPS building/construction insulation materials, and to a more limited extent, WEEE from casings for TVs etc. made of HIPS and treated textiles in vehicles ending up in the shredder waste. The estimated disposal of HBCDD as post-consumer waste in Denmark is shown in TABLE 16. Considering the estimates provided in for the entire EU in 2010 by ESWI (2011), the right values for textiles and HIPS are likely in the lower end of the ranges.

The concentration of HBCDD in flame-retarded EPS used in Denmark was typically 0.5-1.0%, whereas in XPS it was 1.0-2.0% (Lassen *et al.*, 1999). The concentration in these materials when they become waste is higher than the 1,000 mg/kg limit value of the POPs regulation.

TABLE 16. Estimated disposal of HBCDD in post-consumer waste in Denmark

Product group	Concentration in materials	Potential quantities of HBCDD, t/y *3	Disposal method in Denmark
EPS for construction	0.5-1.0 % *1	1-10	Municipal waste incineration
XPS for construction	1.0-2.0 % *1	0.5-5	Municipal waste incineration
Textiles, furniture	Average: 25 % of the coated layer; 8% of the weight of the textile *2	2-10	Municipal waste incineration
Textiles, transportation	Same	5-30	Shredder waste for landfilling or incineration
HIPS in electrical and electronic equipment	Average: 4 % *2	2-4	WEEE treatment

*1: Source: Lassen *et al.*, 1999; *2: Source: ESWI, 2011; *3: Quantities roughly estimated on the basis of the quantities of HBCDD used in Denmark in 1997 and more recent information on the use in EU (as summarised in Lassen *et al.*, 2014b). It is considered that the service life time of EPS/XPS for construction (mainly below ground) is typically more than 50 years, and the quantities disposed of today are well below the consumption 20 years ago.

Fate by incineration. No data on the efficiency of Danish waste incinerators for destruction of HBCDD has been identified. The actual destruction efficiency for HBCDD in Danish incineration plants is currently under evaluation in an assessment for the Danish EPA.

In a desktop study on destruction of persistent organic compounds in combustion systems by Umeå University for the Swedish Environmental Protection Agency, Lundin and Jansson (2017) concluded that HBCDD is destroyed in MSW incinerators operated with a temperature of ≥850ºC and not reformed in the post-combustion zone. However, brominated phenols, that can form brominated dioxins PBDD/PBDF, may be present in the flue gases. Several of the reviewed studies demonstrated destruction efficiencies of 99.999% or better. Lundin and Jansson (2017) consider the number of studies too limited and state that mass balance studies are necessary to confirm that the destruction efficiency is better than 99.999%.

Sewage sludge No data on HBCDD in sewage sludge in Denmark have been identified. Swedish investigations into two WWTPs found levels of HBCDD ranging from below the level of detection to 0.022 mg/kg dw (Wahlberg, 2016). HBCDD levels were well below the levels of decaBDE, which ranged from 0.43 to 0.8 mg/kg and were close to the suggested Swedish limit values for decaBDE in sludge (Wahlberg, 2016).

2.3.6.5 HBCDD in food and drinking water

The National Food Institute at the Technical University of Denmark (DTU Food, 2013) has evaluated the content of HBCDD in several species of fish (cod, eel, herring, mackerel, plaice, salmon and trout) sampled in the Baltic Sea and the North Sea in the period 2002-2006. Fat fish such as herring, mackerel and salmon contained higher levels (1.49 to 6.35 ng/g ww; predominantly the α-congener) than cod, which only had a concentration of 0.02 ng/g ww (whole fish; the liver showed a level of 16.7 ng/g ww). A risk assessment for Danish children and adults was carried out on this basis and it was concluded by the authors that the observed

HBCDD levels "are not of food safety concern", as the calculated Margins of Exposure (MOE) in all cases was at least 1,000,000.

In 2015 and 2016, the Danish Veterinary and Food Agency (Fødevarestyrelsen, 2015b and 2016e) investigated samples of farmed trout (10 samples each year; 5 freshwater fish and 5 marine water fish) and found concentrations of α-HBCDD (being the dominant HBCDD) of 0.06-0.17 ng/g ww in 2015 and 0.05-0.26 ng/g ww in 2016. The authors considered the observed levels to be low.

No Danish drinking water investigations of HBCDD have been identified. The substance is not included in the national Danish monitoring programme for micro-pollutants in ground and drinking water.

2.3.6.6 Total human exposure in Denmark

Based on the commonly accepted perception that food is the main source of exposure in the general population (including children) to HBCDD, the level of human exposure to HBCDD in Denmark appears to be low and not of concern regarding human health.

This assessment is in line with the scientific opinion of the EFSA Panel on Contaminants in the Food Chain (CONTAM), who concluded that "current dietary exposure to HBCDDs in the European Union does not raise a health concern" (EFSA, 2011).

Jensen (2014) states, with reference to results from the UK, that exposure to HBCDD in indoor dust may be more important than exposure to HBCDD in food. No data on HBCDD in indoor dust in Denmark is available. Due to the strict requirements with regard to fire safety of upholstery used in homes in the UK and Ireland, the consumption of HBCDD for textiles has been much higher than the EU average. Some furniture in Denmark, e.g. that imported from the UK, may contain HBCDD (Lassen *et al.*, 1999) and it cannot be excluded that a minor part of the population is exposed to higher levels of HCBDD.

2.3.6.7 Releases of HBCDD and presence in the environment

Not many data on the occurrence and concentrations of HBCDD in the Danish environment are available. However, in 2014, the Danish Nature Agency published a screening report on micro-pollutants in the aquatic environment (Vorkamp *et al.*, 2014) in which HBCDD was also included.

Analyses of water and fish in aquatic as well as marine (coastal) environments (at five locations of each type) were carried out (Vorkamp *et al.*, 2014). HBCDD was identified in all samples of both water and fish. In water, the highest concentrations were found in the freshwater samples (all taken in streams/rivers) in which concentrations at approximately 2.7-2.8 ng/L were found at two locations, just below 1 ng/L at one location and only about 0.1 ng/L at the two last locations. In the marine water samples, the concentrations were lower ranging from 0.05 ng/L to 0.4 ng/L. The two highest concentrations found in freshwater exceeded the EQS of 1.6 ng/L for freshwater, while all the other concentrations were well below the EQS (0.8 ng/L for marine water).

In the fish samples the levels of HBCDD did not differ much between water types (fresh or marine), locations or fish species. Eight out of 10 samples showed contents of HBCDD in the range 0.010 to 0.020 µg/kg wet weight (perch (most of the samples), roach and flounder), while one sample of cod had a lower content (0.005 µg/kg ww) and one sample of eelpout, which is a fish with a high lipid content in contrast to the others, had a much higher HBCDD content of 0.056 µg/kg ww. All the measured values were far below the EQS value for HBCDD in biota of 167 µg/kg ww.

In one of its annual surveys of the marine environment (the 2016 survey), the National Center for Environment and Energy (DCE) also measured HBCDD in fish from three locations (DCE, 2018). However, it is mentioned only that HBCDD was detected in all three samples but in none of them was the EU EQS for HBCDD (167 µg/kg ww) exceeded.

The recent HELCOM core indicator report on HBCDD (HELCOM, 2018a) concluded, based on data reported by the national institutions/agencies responsible for environmental monitoring in the HELCOM countries, that in all samples of fish the levels of HBCDD were well below the EQS value of 167 µg/kg ww (i.e. mean values of more than a factor of 100 below the EQS). The area covered includes the western Baltic Sea and the Kattegat, i.e. inner Danish marine waters.

No criteria for soil quality, cut-off, groundwater quality, or evaporation have been established for HBCDD (Danish EPA 2018)

2.3.7 Annex A and B pesticides

There are no changes in the situation with regard to Annex A and B pesticides compared to the situation in 2012. As there are no known uses of Annex A and B pesticides in Denmark, this section is largely a summary of the description in the previous NIP.

2.3.7.1 Historical use of POP pesticides

As far as is known, only seven of the 15 POP pesticides have ever been used as pesticides in Denmark. The years for entry into force of regulation of the banned POP pesticides in Denmark are listed in TABLE 17.

TABLE 17. Regulation of POPs pesticides in Denmark

Substance	Year of entry into force	Regulation
Aldrin, chlordane, dieldrin, endrin, heptachlor, HCB, toxaphene	1992 2003	Ban on use as active ingredient in pesticides Total ban *
Chlordecone	- 2010	Chlordecone has never been approved for use as a pesticide in Denmark Total ban
DDT	1970 1984 2003	Ban on agricultural use as a pesticide Ban on use as active ingredient in pesticides Total ban *
Lindane (γ-HCH)	1995 2010	Ban on use as active ingredient in pesticides Total ban *
α-HCH and β-HCH	1992 2010	Ban on use of HCH with less than 99.0% gamma isomer as active substance in pesticides Total ban
Mirex	2003	Total ban *
Pentachlorobenzene	1992 2002 2010	Ban on use of Quintozene with a pentachlorobenzene content of more than 10 g/kg Ban on use of Quintozene as active substance in pesticides Total ban *
Endosulfan	1994 2007	Not approved as active substance in pesticides Total ban *

* 'Total ban' means a ban on import, sale and use, except for unintentional trace contaminants and use as a reference material on laboratory scale

The substances are DDT, as well as aldrin, dieldrin, endrin, heptachlor, lindane and endosulfan. Of these, only DDT, dieldrin, endosulfan and lindane have been extensively used, while the others have been sold only in small amounts and were removed from the market in 1963 (aldrin, endrin) and 1972 (heptachlor). Until they were banned in 1992, three substances, α-HCH, β-HCH and pentachlorobenzene may have occurred as impurities in lindane and the fungicide quintozene.

2.3.7.2 POP pesticides in the environment

In the 2010 NOVANA report for the marine environment, all tests for HCB in mussels were less than the BAC[14], while only 56% of the samples were below the BAC for gamma-HCH (lindane). With regard to chlorinated pesticides, an EAC[15] has only been set for gamma-HCH, which was exceeded by 13% of the samples in 2010. The degradation product of DDT, p,p'-DDE, was not included in the 2010 study, but in 2009, the levels in all analysed samples were less than BAC.

The POP pesticides are no longer included in the NOVANA programme regarding emissions to the environment from WWTPs and other point sources. Neither are POP pesticides reported anymore in the national groundwater surveillance (GRUMO) reports (GEUS, 2015).

Only fish are still monitored for content of POP pesticides (DDX, HCB, HCH) as part of the NOVANA programme. In the most recent report for the marine environment (2016) (DCE, 2018), it was only briefly mentioned that these substances were present in the three samples of fish analysed, but at levels below the EQS/EAC values established by the EU or OSPAR.

2.3.8 Intentional use of PCB

This section covers the presence of PCB as the result of its intentional use, while unintentional formation of PCB is included in section 2.3.11 along with other unintentionally formed POPs.

The previous NIP included a number of actions on PCB:

- 19 initiatives in the Danish Government's "Action Plan on Managing PCB in Buildings – Indoor Environment, Working Environment and Waste" addressing:
  - Identification of PCB in buildings,
  - Management of PCB in buildings,
  - Disposal of building waste containing PCB,
  - PCB and health, and
  - Easily accessible guidance and information
- A possible limit value for PCB in sludge, and soil quality standards for PCB
- Examination of the possibilities for identifying PCBs in shredder waste (addresses in section 2.3.12 on POPs in waste).

The PCB Action Plan was implemented by a number of authorities which shared the areas of responsibility. These were:

- Danish EPA – guidelines on waste management for PCB
- Danish Working Environment Authority – occupational safety and health in connection with PCB

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[14] BAC = Background Assessment Criteria

[15] EAC = Environmental Assessment Criteria

- Danish Health Authority – recommended action levels
- Danish Patient Safety Authority – health assessments
- Danish Energy Agency - inventory of PCB in buildings; guidelines on PCB remediation in buildings
- Ministry of Housing, Urban and Rural Affairs - regulations for housing and rooms harmful to health
- Agency for Palaces and Cultural Properties - government buildings.

The following section starts with a description of the results of the PCB action plan in buildings in a number of sub-sections, including a section on PCB containing building waste. This is followed by sections addressing PCB in electrical equipment waste, incineration of PCB-containing waste, PCB in sludge and soil, PCB in food and indoor air and finally PCB in breast milk.

2.3.8.1 Results of national inventory of PCB in building materials and the indoor environment

A national inventory of PCB in building materials and the indoor environment was undertaken in 2013 (Grontmij/COWI, 2013). The inventory included more than 2000 samples from 352 buildings from the PCB period (in Denmark, 1950-1977). The results were combined with surveys of 669 public buildings undertaken by municipalities and a survey of 300 buildings owned by the Danish Forces.

The overall results by building type are shown in TABLE 18. For the majority of buildings, PCB could be measured in concentrations of 0.1 mg/kg in one or more materials. A large proportion of the paints in particular contained low levels of PCB. Concentrations above 50 mg/kg, which render the materials to be disposed of as hazardous waste, could be found in a large number of buildings, the highest percentage being in private office buildings (23-51 % of the buildings).

TABLE 18. Percentage and number of buildings from 1950-1977, which contained PCB in sealants, paint and flooring in 2013 (Grontmij/COWI, 2013**)**

Building type	**Percentage and number of buildings from the PCB period in Denmark with materials above the indicated PCB** concentration (90% confidence intervals)**		
	≥0.1 mg/kg	**≥50 mg/kg**	**≥5,000 mg/kg**
One- and two-family houses	390,000-470,000 67-79%	80,000-140,000 13-24%	20,000-60,000 4-11%
Apartment buildings	12,600-14,100 84-95%	3,600-5,900 24-40%	1,000-2,700 7-18%
Private office buildings	13,900-19,900 60-86%	5,300-11,800 23-51%	1,700-7,000 8-30%
Public institutions and office buildings *	In sealants 4,700-5,700 22-27% In paint and flooring 13,000-18,000 62-83%	In sealants 2,100-2,900 10-13% In paint and flooring 2,400-6,500 11-30%	In sealants 1,200-1,800 6-9% In paint and flooring 300-2,800 1-13%

* Many of the building contain both sealants and paints with ≥ 50 mg/kg PCB, so the total number is significantly below the total of the two ranges.

** Measured as 5 times the sum of 7 indicator PCBs.

Besides the sampling of sealants, paints and flooring in the buildings, the inventory included investigation of sealants (glue) of 1,188 double-glazed windows disposed of as waste and of small capacitors in 516 fluorescent fixtures disposed of with electrical and electronic equipment waste. Furthermore, investigations of secondary (diffusion to adjacent materials) and tertiary PCB contamination (via the indoor air) were undertaken.

Based on the survey results, the total amounts of PCB in building materials and small capacitors in Denmark in 2013 were estimated. The majority of the PCB was estimated to be present in sealants, double-glazed windows and capacitors in fluorescent tubes.

TABLE 19. Remaining quantities of PCB in buildings in Denmark in 2013 (Grontmij/COWI, 2013)

Material/equipment	Remaining quantities of PCB ** Tonnes	% of total
Sealants around windows and doors	7 - 35	40%
Sealants between other building parts	2 - 15	16%
Paint	0.3 - 5	5%
Flooring	0.1 - 2	2%
Double-glazed windows	5 - 15	19%
Capacitors in fluorescent tubes	2 - 7	9%
Secondary and tertiary contamination *	0.7 - 7.5	8%
Total	17 - 87	

* The secondary and tertiary contamination is due to contamination from primary materials by diffusion to adjacent materials or via evaporation to the indoor air.

** Calculated as pure PCB.

The national inventory also included measurements of PCB in the indoor air of 67 buildings and the results were combined with the results of 1,377 indoor air measurements at 507 sites undertaken by the municipalities. The estimated number of buildings with high PCB content in indoor air is summarised in TABLE 20. The sources of high content of PCB in indoor air were both PCB-containing materials (primarily sealants) and leaking capacitors of fluorescent tube fixtures.

The results showed a relatively high percentage of schools with high PCB indoor air concentrations. PCB levels of more than 300 ng/m^3 was found in 13% of 126 investigated schools.

TABLE 20. Estimated number of buildings in Denmark in 2013 with more than 300 ng/m^3 PCB in the indoor air (Grontmij/COWI, 2013)

	Number of buildings from the PCB* period (90% prediction interval)	
	300-3,000 ng/m^3	≥3,000 ng/m^3
One- and two-family houses	18,900-22,000	390-810
Apartment buildings	590-750	7-31
Public institutions and public and private office buildings	1,600-2,400	30-230

* Measures as 5 times the sum of 7 indicator PCB.

2.3.8.2 PCB in construction and demolition waste - requirements of the Statutory Order on waste

In order to safeguard that PCB-containing construction and demolition waste is disposed of in accordance with the regulation, specific requirements for screening of PCB in materials before renovation or demolition of buildings, including replacement of double-glazed windows, were included in the Statutory Order on Waste (Affaldsbekendtgørelsen BEK No 1309 of 18/12/2012) as part of the Action Plan on Managing PCB in Buildings

2.3.8.3 Guidelines for surveys and management of PCB in building materials

With the aim of assisting building owners, contractors and waste companies with the identification and proper management of PCB containing materials/equipment, the Danish EPA has published a number of guidelines:

- Guidelines on management of PCB-containing capacitors in fluorescent light fixtures (Langeland *et al.*, 2015a).
- Guidelines on management of PCB-containing double-glazed windows (Langeland *et al.* 2015b).
- Guidelines for selective demolition and disposal of PCB-containing waste (Alslev *et al.*, 2013a, b, Andersen *et al.* 2013).

Furthermore, the Danish Building Research Institute has developed two detailed instructions for screening and management of PCB in buildings:

- Investigation and evaluation of PCB in buildings (SBI, 2015).
- PCB in buildings – remediation, renovation and demolition (SBI, 2016).

The instructions act as guidelines for professional building owners, advisors and contractors for the part of the Statutory Order on Waste which concerns PCB.

In order to assist building owners in planning for PCB remediation, the Danish Energy Agency published an investigation of typical costs of PCB remediation of buildings contaminated at various levels (Grontmij/COWI, 2014).

2.3.8.4 PCB capacitors in fluorescent light fixtures

The national survey of PCB in buildings mentioned above demonstrated the widespread presence of PCB in small capacitors of fluorescent light fixtures and that leaking PCB from capacitors may lead to PCB levels in indoor air above the recommended action levels. As a consequence, the Danish EPA published a guidance on identification and proper handling of PCB-containing capacitors.

In order to encourage building owners to replace the old fluorescent light fixtures, in 2018 the Danish EPA introduced the campaign "Få PCB frem i lyset"[16] (only available in Danish).

2.3.8.5 Development of sampling and tests methods

A challenge for the implementation of the requirements of the Statutory Order on Waste for PCB screening is the costs of analysis and the time lost between when samples are taken until the results are available. In order to develop faster and cheaper screening methods, the Danish EPA supported a project on development of new sampling and analysis methods (Høegh and Witterseh, 2016).

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[16] https://mst.dk/affald-jord/affald/saerligt-for-borgere-om-affald/pcb-i-armaturer-til-gamle-lysstofroer/

2.3.8.6 Health assessment of PCB in the indoor environment and action levels

One of the actions of the PCB Action Plan was a reassessment of the Danish Health Authority's recommended action levels for PCB in indoor air.

Based on a review of the health risks of PCB in the indoor climate in Denmark (Jensen, 2013), the Danish Health Authority has maintained the recommended action levels for PCB in indoor air as follows (PCB Guiden, 2018):

- **Exceeding 3,000 ng/m^3** (measured as ΣPCB[17]): It is assessed that remaining in the room for long periods may be associated with significant health risk and in most settings it should be regarded as an immediate health hazard. It is recommended that source removal and/or sealing be carried out without unnecessary delay, even in buildings that are used only part of the day.

- **Between 300 and 3,000 ng/m^3**: It should be assumed that remaining in the room for long periods may contribute to health effects. It is recommended that temporary preventive measures be immediately implemented and, in many cases, source removal and/or sealing would be required to bring the level below 300 ng/m^3.

The recommended actions levels are not legally binding but are rather used as guidelines for local health officers who advise the municipal building authorities about the importance of indoor air for the health of the building users.

2.3.8.7 Easily accessible information on PCB

An online inter-ministerial PCB guide and helpdesk have been established (www.pcbguiden.dk) as one of the initiatives under the Action Plan on Managing PCB in Buildings. The guide is updated as new information is obtained.

2.3.8.8 PCB in building waste

According to the Danish EPA's Waste Database System[18] (Danish: Miljøstyrelsens affaldsdatabasesystem, ADS), the quantities of PCB-containing building and renovation waste have increased steeply from around 800 tonnes in 2011 to around 8,000 tonnes in 2014 (FIGURE 2). As shown in the previous NIP, the quantities disposed of in 2007 and 2008 were as low as 50 t/year. This change reflects the improved management of PCB-containing building waste because of increased focus on PCB in buildings and the requirements of the statutory order on waste regarding PCB screening/mapping of building and construction before renovation or demolition, as well as a requirement for reporting the generated amounts of PCB containing waste and its handling to the municipality. It is permitted to use crushed concrete and bricks, which contain up to 2 mg/kg PCB_{total}, in certain types of construction projects. Many of the MSW incinerators currently have permits to incinerate combustible waste with PCB_{total} concentrations of up to 50 mg/kg. Non-combustible waste with concentrations below 1 mg/kg PCB_{total} may be disposed of in landfills for inert waste, whereas waste of 1-50 mg/kg can be disposed of at landfills for mineral or mixed waste. All types of waste with > 50 mg/kg have to be disposed of as hazardous waste for destruction.

The following figures indicate the EAK waste coding numbers for each category of waste.

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[17] Measured as five times the sum of seven indicator congeners.

[18] Data are available at ADS portal at https://www.ads.mst.dk

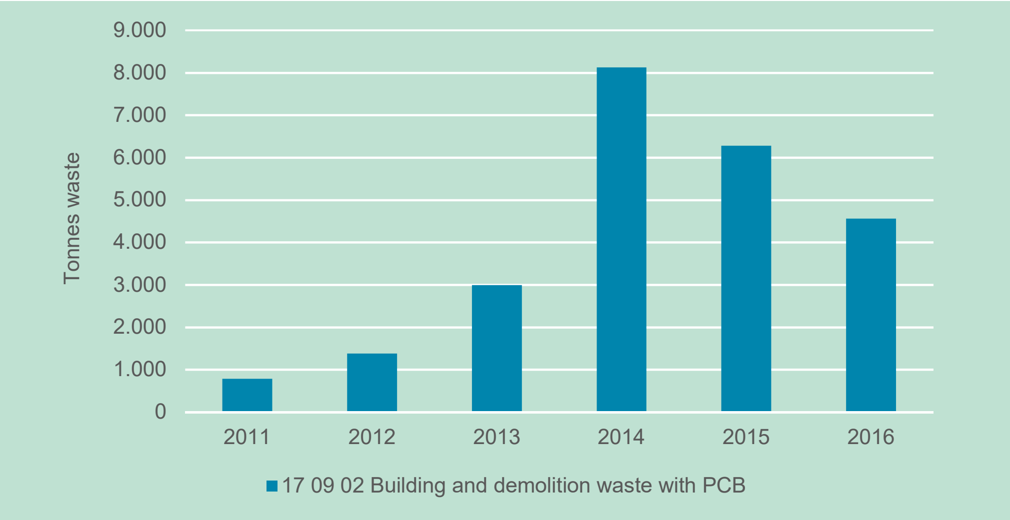

FIGURE 2. Registered quantities of waste of the category building and demolition waste containing PCB from Danish waste producers in the Danish EPA's Waste Database System. The concentration in the waste is not indicated, but waste with any concentration above the detection level may be registered as PCB-containing waste.

The limit values applied for PCB in building waste are summarised in section 2.2.5.8.

2.3.8.9 PCB in electrical equipment and oils

Registered quantities of transformers and capacitors (containing PCB) waste are shown in FIGURE 3.

The Danish EPA has been made aware that some PCB-containing transformers, should have been disposed of before January 2000 which in accordance with the Statutory Order on PCB/PCT, may still present in the waste stream. As a consequence of the registered quantities, in 2015 the Danish EPA sent a letter to the power production and distribution companies informing them about the requirements regarding PCB in large transformers and capacitors.

In order to better understand the background for the data and the actual management of the waste, an investigation has been initiated by the Danish EPA. The investigation that will be completed by the end of 2018 indicates that large PCB-transformers (> 500 ppm) have been disposed of in Denmark. The investigation also indicates that a smaller number of large PCB-capacitors may still be present in Denmark.

Low concentrations of PCB (< 50 ppm) are still found in large transformers and capacitors that are being disposed of in Denmark. The source of the low concentrations of PCB in large transformers and capacitors is believed to be residues of PCBs that were not completely removed when transformers were decontaminated, PCB-contamination on the production site and/or use of regenerated PCB-containing oil.

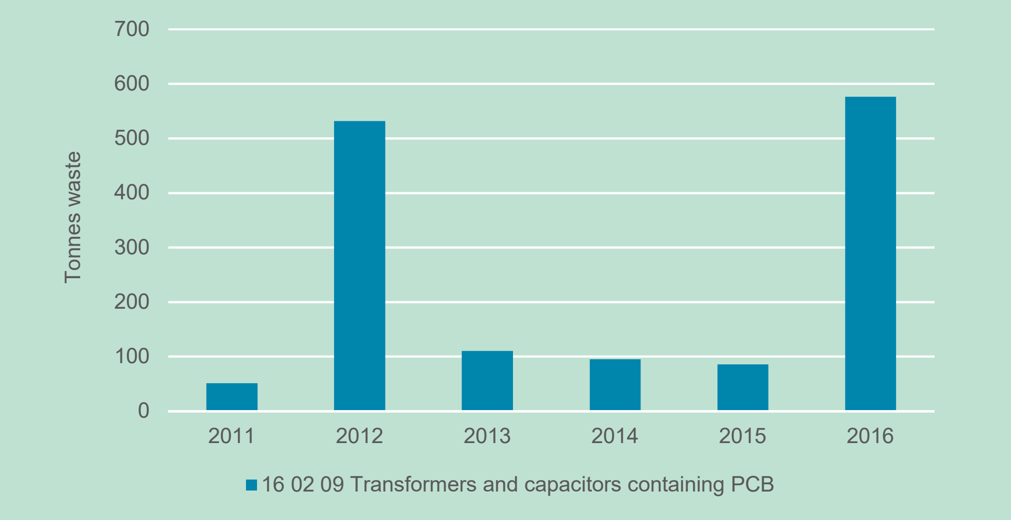

FIGURE 3 Registered quantities of the category "transformers and capacitors" containing PCB disposed of from Danish waste producers.

Registered quantities of insulation and heat transmission oils containing PCB as well as components from end-of-life vehicles containing PCB are shown in FIGURE 4. The interpretation of the data is included the ongoing assessment.

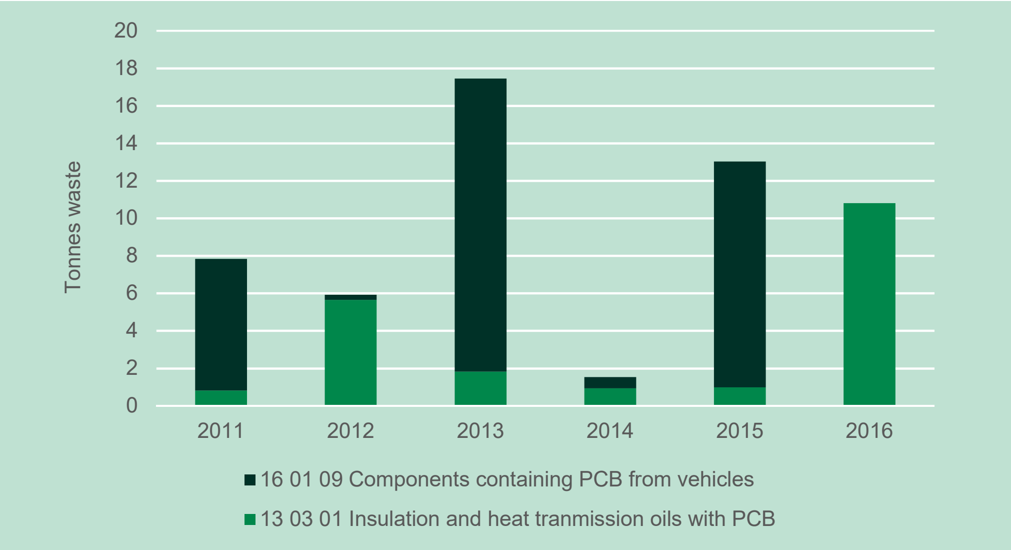

FIGURE 4. Registered quantities of the categories of components containing PCB from end-of-life vehicles and insulation and heat transmission oils with PCB

The Danish EPA's Waste Database System also contains information on two other waste categories containing PCB: 13 01 01 Hydraulic oils containing PCB and 16 02 10 Discarded equipment containing or contaminated with PCB. A closer analysis of the registered quantities shows that the waste is registered by a few companies and that the waste is most likely registered under the wrong waste codes and is not PCB-containing.

2.3.8.10 Incineration of PCB-containing waste

A review of PCB-containing waste disposed of to MSW incinerators states that the destruction/removal efficiency of low-level PCB in waste was 90-99 % of PCB content for waste with a PCB content of < 50 mg/kg (Jensen and Dalager, 2015). The study notes that addition of shredder waste will most likely increase the PCB concentration of the waste and increase the

PCB concentration in the raw flue gas and bottom ash 2-5-fold. Most PCB in the waste will be destroyed if the combustion process is as optimal as possible regards high temperature, long residence time, and appropriate oxygen pressure. It is further noted that a regular and constant operation of the incineration plant is important, because start-up and close-down of operations diminish the destruction of PCB and increases new-formation and emission of PCB (and dioxins) from the municipal waste incinerators considerably (Jensen and Dalager, 2015).

The majority of the PCB which is not destroyed will end up in fly ash and other flue gas treatment residues. Modern MSW incinerators with "dioxin filters" are able to remove > 99% of the dioxin-like PCB from the flue gas and only about 1% of the PCB in the raw flue gas is emitted to ambient air (Jensen and Dalager, 2015). The study concluded that it had not been possible to make an adequate assessment of literature data that could theoretically be directly applicable to the conditions at the individual Danish incinerator plants (Jensen and Dalager, 2015). The study suggests that a more thorough investigation may be required.

2.3.8.11 PCB in sewage sludge

One of the actions of the previous NIP was to establish a limit value for PCB in sludge. A limit value of 0.2 mg PCB_7 per kg dry matter sludge has been established by the Statutory Order on agricultural use of waste (BEK no. 1001 of 27/06/2018). The limit value applies only to sewage sludge from public WWTPs and private WWTPs treating household wastewater.

The risk evaluation by Jensen *et al.* (2012) concluded that it was highly unlikely that the levels of PCB found in Danish sludge should pose a significant risk to soil-dwelling organisms and soil quality in general, if the current application guidelines of sewage sludge are followed.

An investigation of PCB and dioxins in sludge from Danish food processing industries exported to Germany found a maximum of PCB_6 (used for the German limit values) of 0.06 mg PCB_6/kg dry matter (Bagge, 2012) in 128 samples. All samples had PCB_6 concentrations below the German limit value of 0.2 mg PCB_6/kg dry matter. The concentration of PCB_6 would typically be slightly below the concentration of PCB_7 and all sludge samples are likely to be below the current Danish limit value. Please note that the Danish limit value does not apply to sludge from food processing industries.

2.3.8.12 PCB in soil and soil quality criterion

One of the actions of the previous NIP was to establish a soil quality criterion for PCB.

Based on an evaluation of health hazards related to exposure to PCB, Larsen *et al.* (2014) concluded that a health-based soil quality criterion for PCBs was not considered to be relevant. According to the authors, the health-based quality criteria for chemicals in soil are primarily aimed at protecting children who may ingest soil or come into dermal contact with the soil. PCBs, particularly the highly chlorinated congeners, adsorb strongly to soil particles and both oral and dermal absorption from soil is therefore considered to be lower than the absorption of PCB from food. A scenario of children's exposure to PCB showed that the contribution from soil to the intake of PCBs for young children during their two first years of life would have a negligible impact on the daily intake of PCB by children and on the PCB body burden in adulthood (Larsen *et al.*, 2014).

No criteria in relation to soil and groundwater quality regarding PCB have been established (Danish EPA, 2018).

According to Larsen *et al.* (2014), the Danish EPA concluded that the content of PCB in soil seldom exceeds 0.5 mg PCB_7/kg dry matter and, rarely, 1 mg PCB_7/ kg dry matter based on current investigations of PCB in soil. Some point sources may exceed this level.

Investigations of PCB content in the topsoil were carried out on three sites with known presence of PCB in the outer building materials (e.g. sealants). The maximum levels of the three sites were measured at 0.03, 0.11 and 4.45 mg PCB_7/ kg dry matter (Nielsen, 2014). The highest level of PCB_7/ kg dry matter was measured at 6 metres from the building.

Another investigation summarised data from 96 soil samples from 25 sites in three municipalities around buildings with PCB-containing materials (Haven, 2014). The maximum level measured was 0.45 mg PCB_7/kg dry matter while the mean concentration of all measurements was 0.02 mg PCB_7/kg dry matter. The highest concentrations were found within a distance of 0.5 m from the buildings. The highest measured concentration at nine sites, where PCB contamination from the buildings was considered insignificant, was 0.009 mg PCB_7/kg dry matter.

2.3.8.13 PCB in food

Dioxin-like PCB congeners are monitored in food along with dioxins; data are shown in the section on unintentionally formed POPs. Even dioxin-like PBCs may originate from intentional uses. Ten other indicator PCB congeners are monitored along with the monitoring of chlorinated pesticides.

According to a review of the 2012-2013 monitoring results (Petersen *et al.*, 2015b), lean fish have appreciably lower levels of organochlorine pesticides and indicator PCB than fat fish such as herring. The highest levels were found in cod liver (mean 299 ng/g) and eels (mean 18 ng/g). In eggs, two of 42 samples were positive, with a maximum of 109 ng/g. These findings in 2012-2013 were consistent with findings in the previous monitoring period 2004-2011. According to the previous review (Petersen *et al.*, 2015a), the level of indicator PCB level in food has reached a largely steady state.

The 2012-2013 review does not include an estimate of total dietary exposure. According to the 2004-2011 review (Petersen *et al.*, 2015a) "*for non-dioxin-like PCB a TDI of 10 ng/kg bw/day has been proposed for the sum of 6 PCB congeners (PCB-6) and a TDI of 20 ng/kg bw/day has been proposed for total PCB. The mean dietary exposure of PCB-6 was estimated to 1.8 ng/kg bw/day for the total Danish population (aged 4-75). For children (aged 4-14) the mean exposure is estimated to be 2.7 ng/kg bw/day. For indicator PCB measured as a sum of 10 PCB congeners the exposure is estimated to be 5.7 ng/kg bw/day for the total Danish population (aged 4-75) and 8.9 ng/kg bw/day for children (aged 4-14). Less than 1 % to 5 % of the population groups exceed the proposed TDI for non dioxin-like PCB.*

For the Danish population, fish and fish products are the main contributors to the exposure (about 32%) followed by dairy products (about 25%), fat and fat products (about 22%) and meat and meat products (about 18%)"

PCB in food may originate from intentional use of PCB but may also be due to unintentional formation of PCB.

2.3.8.14 Exposure to PCB in indoor air

The general population can be exposed to PCBs by ingestion of contaminated food, by inhaling contaminated air and by contact with contaminated soil and dust particles. Food consumption is by far the major contributor to the body burden of PCBs; more than 90% comes from dietary exposure (Larsen *et al.*, 2014).

For some groups of the population, exposure to PCB in the indoor environment may contribute significantly. In “Farum Midtpunkt”, a building complex with approximately 300 PCB contaminated apartments out of 1645, the mean concentrations of PCB_6 (without correction) in blood plasma (fresh weight) from 139 PCB-exposed individuals living in PCB-polluted apartments was 3.5 µg/L (range: 0.2-16 µg/L) (DHMA 2012 as cited by Jensen, 2013). The mean concentration of PCB_{27} was about double the mean at 6.8 µg/L (range: 0.4-29 µg/L). The means of the controls were respectively 1 and 1.5 µg/L, i.e. the exposed individuals had about four-fold higher PCB levels than the controls. Likely because of lactation periods, females had lower levels than men as expected. In addition, there was a clear increase in PCB levels by age, which may be caused by longer exposure time and previous higher PCB levels in food.

One of the conclusions of the assessment of exposure in the indoor environment was that current knowledge on long-term health effects of exposure to PCBs do not allow for appropriate risk assessment of indoor air exposure (Bonde, n.y.). The reason is that PCBs released from indoor sources have a high content of lower chlorinated and semi-volatile PCBs that are mostly non-dioxin-like. As current risk paradigms on PCB rely entirely on the dietary sources and dioxin-like PCB congeners, there is a current gap in knowledge on long-term health effects following airborne PCB exposure in homes and schools. (Bonde, n.y.). With the aim to unravel whether high-level exposure to indoor PCB released from building materials is associated with reproductive health risk, a research programme, HESPERUS, with participation of a number of Danish and foreign research institutions has been initiated. The programme links indoor air measured exposures to PCBs in Denmark with a number of health outcomes from nationwide registers to form the basis for an ongoing research programme. The study will be the first in a series of investigations on long-term health effects of the lower-chlorinated, semi-volatile PCBs in the indoor environment (Bräuner *et al.*, 2016).

Morrison *et al.* (2018) have investigated the ability of clothing to sorb PCBs from contaminated air in buildings and thereby influence exposure. The equilibrium concentration of PCB#28 and PCB#52 was quantified for nine used clothing fabrics exposed for 56 days to air in a Danish apartment contaminated with PCBs. According to the results, clothing acts as a reservoir for PCB that extends dermal exposure, even when outside or in uncontaminated buildings.

2.3.8.15 PCB in breast milk

According to the previous NIP from 2012, PCB measurements over time show that the general level of PCB in breast milk and blood in Danes has decreased by about three-quarters since the ban on use of PCB in the 1970s. However, the concentrations of PCB are still quite high compared to other countries. A recent study on the country-specific chemical signatures of persistent organic pollutants (POPs) in breast milk of French, Danish and Finnish women found that the observed exposure levels of non-dioxin-like PCBs were higher in Danish women (163 ng PCB_6/g l.w.) compared to Finnish (104 ng PCB_6/g l.w.) and French women (85 ng PCB_6/g l.w.) (Antignac *et al.*, 2016). As the concentration is decreasing, the comparison is highly sensitive to the years the particular investigations compared were carried out. The samples from France were from 2011-2014, whereas samples from Denmark and Finland were from 1997-2002; the data consequently cannot be directly compared. Krysiak-Baltyn at al. (2010) previously demonstrated that Danes generally have higher exposure to POPs than Finns.

2.3.9 PFOS

The previous NIP listed a number of actions to take for PFOS:

- Report on current use of PFOS in Denmark and notification of acceptable uses
- Information to users of PFOS on acceptable uses in Denmark
- Study of PFOS/PFOA as soil and groundwater contamination
- Assessment of the presence of PFOS in household waste
- Validation of destruction of PFOS
- Possible requirements for separating household waste containing PFOS.

A survey of PFOS, PFOA and other perfluoroalkyl substances was undertaken as part of the Danish EPA's surveys of substances on the List of Undesirable Substances, LOUS (Lassen *et al.* 2013b). Based on the results of the survey, the Danish EPA developed a strategy for risk management of PFOS and PFOS-compounds (Danish EPA, 2013). The strategy listed four measures:

- Encourage the European Commission to validate the extent to which PFOS is destroyed in waste incinerators
- Evaluate the further need for assessment of the risk of groundwater contamination from PFOS-contaminated sites
- Develop criteria at the EU level for endocrine disruptors and the process concerning combination effects (address PFAS in general and not specifically PFOS)
- Follow the action plan for reduction of the remaining uses of PFOS in the EU.

2.3.9.1 Current PFOS use in Denmark

The production and marketing of PFOS for a number of specific uses have so far been allowed in the EU under certain conditions. These conditions are stated in section 2.2.4.

Mist suppressant. PFOS had until recently been used as a mist suppressant in non-decorative hard chromium plating in Denmark but has now been phased out. Around 2010, 10-28 kg of PFOS were used annually in hard chromium plating by about five small enterprises in Denmark. The most commonly used PFOS substance for this purpose was tetraethylammonium perfluorooctanesulfonate (CAS no. 56773-42-3). A search on data on the substance tetraethylammonium perfluorooctanesulfonate (CAS no. 56773-42-3) in the Danish Product Register shows that, in 2014, four products were registered. For 2015 the number of products is indicated as "0", meaning that fewer than three products were used, while for 2016 no products were indicated, clearly showing that the substance is no longer used in Denmark. All uses of the substance have been phased out.

According to information from former users and the importer of the mist suppressant for the five companies, the PFOS-based mist suppressant has been replaced in all companies by a PFOS-free mist suppressant, Ankor Dyne 30 MS. The agent contains another PFAS: 1H,1H,2H,2H-perfluorooctane sulfonic acid (CAS no. 27619-97-2; 6:2 fluorotelomer sulfonate) (Bleep *et al.*, 2017).

The alternative mist suppressant was previously tested in an investigation of possible alternatives to PFOS in hard chrome plating in Denmark (Poulsen *et al.*, 2011). The tested agent was Fumetrol® 21, but with the same substance: 1H,1H,2H,2H-perfluorooctane sulfonic acid. According to the study, the non-PFOS alternative is an environmental improvement as it is less persistent, less bioaccumulative, and less toxic than PFOS. The effectiveness, the durability, and the cost level were reported as being similar to that of the PFOS-based mist suppressant under the pilot-scale test (Poulsen *et al.*, 2011). The price of the alternative was slightly lower than the PFOS-based mist suppressant, but slightly higher quantities were used which could also result in increased costs of waste disposal. All in all, the running costs were similar for the two mist suppressants in the pilot scale test. According to the test on the alternative, the one-off costs needed for changing from PFOS to the alternative mist suppressant were assessed as zero since the alternative could be directly added to the chrome bath instead of PFOS (Poulsen *et al.*, 2011).

Information on the experience with the new substances at full scale has been obtained from one user with detailed knowledge on several of the companies. According to the user, the overall costs of the alternative are higher that the PFOS-based mist suppressant. The price of the alternative is indicated to be 2.3 times the price of the PFOS-based product, but it lasts for shorter periods. Therefore, the overall the costs of the alternative are 3-4 times the cost of the PFOS-based mist suppressant. Experience with the technical challenges with the use of the alternative at full scale is limited. According to one user, the alternative is less efficient and lasts for a shorter time; in addition, more manual monitoring of the process is needed. The higher price of the alternative was confirmed by the importer.

Other potential applications - A survey of possible applications of PFAS by Nicolaisen and Tsitonaki (2016) mentions that 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-n-(2-hydroxyethyl)-n-methyl-1-octanesulfonamide (CAS no. 24448-09-7), which may serve as a PFOS precursor, has been used in Denmark. According to data from the SPIN database, the substance has not been notified to the Product Register since 2009.

The LOUS survey of PFAS (Lassen *et al.*, 2013b) includes a Product Register search of many hundreds of substances from the OECD lists of PFAS. The list of substances registered in the Product Register includes 13 substances within the OECD group of PFOS and PFOS precursors. Of these, quantities are only provided for one substance, whereas the data are confidential for the other. The substance is glycine, potassium n-ethyl-n-[(heptadecafluorooctyl) sulfonyl] glycinate (CAS No. 2991-51-7). The substance is not directly listed in Annex B to the Convention, but may be degraded to PFOS (POPRC, 2010) and is restricted under the POPs Regulation. According to the SPIN database, in 2016 eight preparations were registered within the application area "Cleaning/washing agents". The total quantity was registered at <50 kg. The MFVM will take action to stop any remaining use of the substance.

2.3.9.2 PFOS in new textiles and rugs

In some studies, PFOS has been detected at trace levels in textiles treated with PFAS-based agents for water and dirt repellence e.g. for textiles and rugs. Two recent Danish studies of PFAS in textiles and rugs for children did not find PFOS in any significant concentration in the articles as further described below.

In a survey and risk assessment of per- and polyfluoroalkyl substances (PFAS) in textiles for children, concentrations of PFOS were below 0.21 µg/m² in all samples i.e. well below the POPs Regulation limit value of 1 µg/m² (Lassen *et al.*, 2015). It should be noted that the study found a number of other PFAS in higher concentrations than the concentration of PFOS. The majority of the PFAS was present as side-chain fluorinated polymers with side chains with various perfluorinated moieties. Due to the low concentrations, no Risk Characterisation Ratio (RCR) was estimated for PFOS.

A survey and risk assessment of chemical substances in rugs for children found a PFOS concentration above the detection limit in one of the analysed rugs (Klinke *et al.*, 2016). The PFOS concentration in the textile surface of the rug was 0.42 µg/g while iso-PFOS (no CAS No indicated) concentration in the same sample was 0.59 µg/g. The sum of these numbers was far below the limit value of the POPs regulation of 0.1%. The estimated Risk Characterisation Ratio (RCR) for PFOS was estimated at 0.0003 while the RCR for total PFAS+PFOA was estimated at 0.0026, i.e. well below 1. If the RCR exceeds 1, the total exposure to the substances is considered to constitute an unacceptable risk.

2.3.9.3 PFOS in waste

The previous NIP included an assessment of PFOS in waste where the main waste categories are carpets (by far the major source of PFOS in waste), leather upholstery in furniture and car interiors, as well as other textiles, cardboard and paper. Unused fire-extinguishing foam should already have been disposed of at that time. Based on the assessment of PFOS in waste in the EU (ESWI, 2011) and the expected lifetimes of the products, it was assessed that virtually all PFOS-containing waste would be disposed of by 2016. However, it cannot be ruled out that some PFOS would still be present in the waste stream because some articles may have lifetimes substantially longer than expected technical lifetimes.

2.3.9.4 Destruction of PFOS by waste incineration

Validation of the destruction of PFOS in municipal waste incinerators is one of the actions proposed by the previous action plan. So far, robust conclusions regarding their destruction have not been obtained. The actual destruction efficiency for FPOS in Danish incineration plants is currently under evaluation in an assessment for the Danish EPA.

The LOUS review of PFOS and other PFAS examined the available studies and observed that some show that PFOS is effectively destroyed at 1,100˚C (comparable to high-temperature hazardous waste incineration), and the studies available suggest that this may also be the case at a temperature of 850˚C. On the other hand, there are no studies which document clearly that destruction is complete at 850˚C (Lassen *et al.*, 2013b).

The updated EU Implementation Plan for the Stockholm Convention states that since the C-F bond is more stable compared to other carbon-halogen bonds, the destruction of PFOS and other PFAS require appropriate destruction technologies, such as BAT hazardous waste incinerators (operated normally at 1.100°C). PFOS-containing materials such as carpets or coated paper end up to a considerable extent in municipal waste incinerators (operated at ≥850ºC). Full-scale tests with assessment of destruction efficiency and degradation products have not been published for municipal waste incinerators and sewage sludge incinerators. According to the implementation plan, it is advisable that Member States share information among themselves and with the Stockholm Convention Secretariat on their experiences with PFOS destruction projects and appropriate destruction technologies (European Commission, 2014).

In a desk study on destruction of persistent organic compounds in combustion systems by Umeå University for the Swedish Environmental Protection Agency, Lundin and Jansson (2017) concluded that the knowledge on how PFOS behaves in combustion processes is scarce, but the consensus in the limited scientific literature is that degradation of PFOS occurs at temperatures above 500°C. According to the review, a study shows that PFOS is not formed as a by-product when perfluoroalkyl substances (PFAS) are burned, and that combustion of fluorotelomer-based polymers is not a source of emissions of PFOS. The authors concluded that a statement that PFOS are destroyed in municipal waste incinerators operating at 850˚C can be made only with a low level of confidence.

The Basel Convention guidelines on management of waste containing PFOS and related substances mention that hazardous waste incineration is one of the destruction and irreversible transformation methods applicable for the environmentally sound disposal of wastes with a content of PFOS, its salts or PFOSF at or above 50 mg/kg (Basel, 2015). The guidelines do not address incineration at lower temperatures.

In conclusion, it is still uncertain as to what extent PFOS is destroyed in MSW incinerators operating at a temperature of 850˚C.

2.3.9.5 PFOS in sewage sludge

For the risk evaluation, Jensen *et al.* (2012) used the highest concentration of PFOS and PFOA found in sewage sludge from Danish municipal WWTPs. According to the study, a comparison of the lowest test concentrations, where no significant effects were observed (NOEL), and the predicted concentrations in soils after sewage sludge amendment, reveals a margin of safety which is on the borderline of what would be acceptable according to the risk assessment procedure outlined in REACH. On this basis, it is concluded that the PFOS levels observed in Danish sludge may pose a long-term risk to the soil ecosystem and that more information on the fate and effects of PFAS is needed (Jensen *et al.*, 2012). The study notes that the restrictions in the use of PFOS in Denmark and the EU are likely to result in lower concentrations in sewage sludge in the future.

2.3.9.6 PFOS in soil and groundwater

In 2015, the Danish EPA established sum criteria for drinking water, groundwater and soil for 12 specific PFAS, including PFOS (Danish EPA, 2018). The sum criterion for drinking water and groundwater is 0.1 µg/l while for soil it is 0.4 mg/kg dry matter.

For implementation of one of the actions on PFOS from the previous NIP, a literature review of soil and groundwater contamination by PFAS (Nikolaisen and Tsitonaki, 2016) and a screening investigation of groundwater of a number of potentially contaminated sites in Denmark were undertaken (Tsitonaki *et al.*, 2014).

PFOS has previously been used in aqueous fire-fighting foams (AFFF). The concentration of perfluorinated substances in AFFF has typically been 0.5-1.5%. It should be noted that other types of PFAS are also used in AFFF and that PFOS was replaced many years ago by other substances. AFFF based on PFOS was produced by the 3M company until 2002. PFOS has in particular been part of AFFF used in airports for extinguishing oil fires and the foams have been used on fire-fighting training grounds. In the screening study from 2014, PFAS was detected in five out of eight investigated fire-fighting training grounds (Tsitonaki *et al.*, 2014). The soil levels varied from a few to several thousand ng/l. The quality of the site investigations varied and investigations sometimes had the character of screening. Four of the sites were considered to be comprehensively studied (several wells in the source area). At two of these sites, PFAS levels were above or close to 100 ng/l, while at another two, levels of more than 1000 ng/l were detected (sum of 9 PFAS compounds). In the remaining four sites, where the site investigations' quality was considered less robust, no PFAS were detected, with the exception of one site at which slightly over 100 ng/L was found (Tsitonaki *et al.*, 2014). PFOS was detected at three of the sites in concentrations ranging from 15 to 980 ng/l. PFOS was the dominant PFOS only at the site with 980 ng/l. It should be noted that the study only included nine PFAS compounds based on the available analytical package. There are at least 38 large fire-fighting training grounds in Denmark. In an independent investigation done voluntarily at one fire training ground and quoted in the study, the level of PFAS was 100,000 ng/l (Tsitonaki *et al.*, 2014, no further information on the site). PFOS was detected in 19 out of 24 samples at levels up to 62,000 ng/l.

A high concentration of PFAS compounds of approximately 1,400 ng/l was found in one sample from the investigated carpet industry. Of this, PFOS accounted for 870 ng/l. The sample originated from a random shallow groundwater well at the site, not situated directly in an area where there was any knowledge of use, storage or spill of PFAS.

The screening investigations in the project did not find high levels of PFAS in four landfills, two chromium plating sites and one paint manufacturer. The extent and quality of the studies in these industries was limited, and the screening study did not allow a definitive conclusion with respect to whether these sites are potential sources for groundwater contamination with PFAS (Tsitonaki *et al.*, 2014).

Nikolaisen and Tsitonaki (2016) state that PFAS have been detected at half of their screened sites. The sum of PFOS, PFOA and PFOSA at these sites is at or above the recommended limit value for drinking water in Germany of 0.1 µg/l (Nikolaisen and Tsitonaki, 2016). The PFAS concentration was also consequently at or above the same level as the Danish sum criteria for drinking water and groundwater of 0.1 µg/l for the sum of 12 PFAS.

A pilot study on possible groundwater contamination with PFOA and other PFAS was conducted within the Danish National monitoring programme, NOVANA (Enevoldsen and Juhler, 2014). The screening study did not demonstrate any widespread high-level contamination with perfluorinated compounds examined in the upper aquifers. In total 57 samples were analysed in the project, collected from 43 sites in Denmark. The study included sampling sites near two fire-fighting training grounds. In samples from one of these sites, small concentrations were detected for PFOS and three of the other PFAS. The levels observed for the PFAS concentrations were at the level of quantification (0.003 and 0.006 µg/l). The authors concluded that although the levels observed may seem low when compared to published effect concentrations, the study demonstrates that there is potential for leaching and subsequent transport of PFAS in aquifers (Enevoldsen and Juhler, 2014).

Nikolaisen and Tsitonaki (2016), in addition to fire training grounds, indicate the following industries as potential sources of soil contamination by PFAS: Chromium plating, carpet, paint, wood, furniture, chemical, iron - and metal, rubber and plastic, and textile and leather. It has not been further investigated as to what extent the use of PFAS in industry has caused local contaminants.

A screening for PFAS in groundwater analysed 45 samples of groundwater for PFOS and 10 other FPAS (Danish Nature Agency, 2015). PFOS was found in two of the samples in concentrations of 0.002 and 0.1 µg/l.

In 2014, the Danish Nature Agency (2014) instructed the municipalities that regular control of drinking water supplies should also include PFAS if there are or have been one or more facilities that may have used PFAS. In order to assist the regions and municipalities, the Danish regions' knowledge centre for environment published a detailed manual in 2018 on investigation and remediation of sites contaminated with PFAS (DRER, 2018).

2.3.9.7 PFOS in food

PFOS in food is monitored by the Danish Veterinary and Food Administration (DVFA) in accordance with the Commission Recommendation of 17 March 2010 on the monitoring of perfluoroalkylated substances in food (2010/161/EU).

In the most recent monitoring campaign from 2017, involving 36 samples of game, meat, egg and milk, PFOS was measured above the detection limit of 0.3 ng/g wet weight in three samples of pork. The concentrations in the range of 0.3-1.4 ng/g were far below the actual action level of 200 ng/g. In 12 samples of farmed fish, the PFOS concentration was below the detection level of 0.4 ng/g in all samples. In wild fish, PFOS was detected above the detection level in nine of 20 samples at levels of up to 1.9 ng/g.

Monitoring of PFOS in vegetables did not find PFOS concentrations above the detection level in any of the ten samples taken in 2015.

The 2012-2013 review of chemical contaminants in food does not include a review of PFOS (Petersen *et al.*, 2015b).

According to the 2004-2011 review and risk assessment on PFOS "*The results for perfluorinated substances in food are relatively sparse, so exposure distributions were not performed and only the mean dietary exposure in ng/kg bw/day for the Danish population aged 4-75 was estimated. For food consumption data on fish species not included in the present survey the most appropriate result from the fish species analysed were used. For PFC results lower than LOD of 0.5 ng/g PFOS, LOD was used as result. Based on these assumptions the mean exposure of the Danish population to PFOS is 27 ng/day or 0.45 ng/kg bw/day. EFSA (2012) have estimated that the highest contributors to dietary PFOS exposure across all age classes were 'Fish and other seafood' (50 to 80 %) followed by 'Fruits and fruit products' (8 to 27 %) and 'Meat and meat products' (5 to 8 %). The present Danish exposure estimate of 27 ng/day or 0.45 ng/kg bw/day is in between the Norwegian and the German results and is low compared to the TDI set by EFSA of 150 ng/kg bw/day. However, unlike the other results, the Danish estimate covers only fish consumption*". And further *"Overall, it is a reason for concern* *that these persistent chemicals are used in food packaging etc. since it takes 20-30 years before they are eliminated from the human body"* (Petersen *et al.*, 2015a).

Some investigations have demonstrated high concentrations of PFAS in food, where the source of the PFAS was per- and polyfluorinated surfactants used for food contact materials, primarily to impart oil and water repellency to paper and cardboard (summarised in the LOUS report of Lassen *et al.*, 2013).

In 2015, the DVFA screened 28 food contact materials for the presence of PFAS (DVFA, 2015). The substances were divided into two groups of substances: those which can be degraded to PFOA and PFCA (perfluoroalkyl carboxylic acids), and those which can be degraded to PFOS and PFSA (perfluoroalkyl sulfonic acids). In all 28 materials, concentrations of PFOA and PFOS precursors were below the detection limit except for one sample. The detection limit was 0.01-8.25 µg PFOA or PFOS equivalent per kg food item, depending on the sample's surface area/volume relationship. All samples had concentrations of total organic fluorine above the previous guiding reference value established by the DVFA. A new indicator value for paper and board food contact materials has replaced this previous guidance value.

In a study of migration of PFAS from food contact materials, the DVFA analysed the content of PFAS in 66 samples of paper and cardboard (DVFA, 2012). In 10 of the samples, the concentration of one or more PFAS was above the detection limit but data are not reported specifically for PFOS or PFOS precursors.

A workshop for the Nordic Council of Ministers proposed, as a possible risk management option, to reduce the total content of organically bound fluorine in paper and cardboard food contact materials (Trier *et al.*, 2018). Subsequently, a level for a Danish recommended limit on total organic fluorine in paper and cardboard food contact materials was suggested by the National Food Institute, DTU Food, in 2016.

In April 2018, the DVFA introduced a new indicator value to help the industry assess whether cardboard and paper have been treated with organic fluorinated substances. The indicator value is 10 µg total organic fluorine per dm^2. Concentrations below the new indicator value are considered to be background contamination. Companies can use the indicator value to ensure that paper is not treated with organic fluorinated substances (DVFA, 2018).

On their website, the DVFA discourages the use of organic fluorinated substances in food contact materials.

2.3.9.8 PFOS in serum of pregnant women

Time trends of PFOS and six other perfluorinated alkyl acids (PFAAs) in serum from Danish pregnant women between 2008–2013 show a decreasing trend for all substances. The decrease in the concentration of PFOS was determined at 9.3%/year (Bjerregaard-Olesen *et al.*, 2016a). The geometric mean concentration of PFOS was 8.0 ng/ml; PFOS represented more than 50% of the total concentration of the seven PFAAs of 14.1 ng/ml. The decreasing trend in PFOS concentrations is in accordance with the general trend in PFOS concentrations in human serum or plasma. The overall trend in European countries is that the PFOS concentrations increased between 1975-1995 to a level in the range of 15-35 ng/ml; however, since 1995, the concentrations have been steadily decreasing (as shown in Bjerregaard-Olesen *et al.*, 2016a). Consistent with this observation, Bjerregaard-Olesen *et al.* (2017b) found higher PFAA concentrations in the older Danish National Birth Cohort for the years 1996-2002. These decreasing trends in PFOS concentrations are expected to be related to the phase-out and ban of PFOS production in the US, Europe, Australia, and Japan (Bjerregaard-Olesen *et al.*, 2016a).

Determinants of serum levels of PFOS and other PFAS in Danish pregnant women was studied in a cohort of 1438 Danish pregnant nulliparous women (Bjerregaard-Olesen *et al.*, 2016b). The total concentration of the PFAS was higher in older women. On average, women of normal weight had higher ∑PFAA levels than those who were underweight, overweight, or obese. For all studied PFAS, higher levels were observed for women of normal weight (as opposed to underweight, overweight, or obese), women without previous miscarriages, women with high levels of education, women born in Denmark (as opposed to women born elsewhere but currently living in Denmark), non-smokers, and women who consumed alcohol before or during pregnancy (Bjerregaard-Olesen *et al.*, 2016b).

2.3.9.9 PFOS in the environment

PFOS contamination of soils and groundwater resulting from releases from point sources including fire-fighting training grounds is described earlier in this section.

DCE (2015) reports results of the GRUMO programme from 1989-2014, which include samples of groundwater taken during a special PFAS campaign at 40 Danish water works (intake depth varying from 3-39 metres below the surface). PFOS was detected at levels above the LOQ (0.002 µg/l) in two of the samples (max. 0.100 µg/l) while PFOA was detected above the LOQ in three samples and PFHxS in one sample. A total of 11 PFAS substances were detected.

DCE (2016b) analysed liver samples of flatfish taken at five locations (marine waters) and transformed the measured concentrations to muscle concentration equivalents. The results showed that the contents of PFOS were below the EQS of 9.1 µg/kg ww (muscle) in all five samples. PFOS constituted 60-76% of the total content of PFAS.

2.3.10 Hexabromobiphenyl, and tetra-, penta-, hexa- and heptabromodiphenyl ether

The previous NIP listed a number of actions to be taken in order to reduce the releases of hexaBB and PBDE:

- Validation of destruction of technical pentaBDE
- Possible separation of household waste containing pentaBDE
- Guidelines concerning non-recyclable mixtures and articles containing pentaBDE
- Examination of the possibilities to identify pentaBDE in shredder waste.

A survey of brominated flame retardants was undertaken as part of the Danish EPA's surveys of substances on the List of Undesirable Substances, LOUS (Lassen *et al.* 2014b). Based on the results of the survey, the Danish EPA developed a strategy for risk management of brominated flame retardants (Danish EPA, 2013). The strategy does not include specific measures for the PBDEs and the hexaBB listed under the Stockholm Convention, but rather focuses on further measures to address the brominated flame retardants still in use.

2.3.10.1 Validation of destruction of technical pentaBDE and octaBDE

One of the main concerns about the incineration of BFR-containing plastics has been the risk of formation of brominated dibenzo-p-dioxins and brominated dibenzo furans (PBDD/PBDF) and mixed polybrominated and polychlorinated dioxins and furans (PXDD/PXDF).

The LOUS survey of brominated flame retardants (Lassen *et al.* 2014b) included a review of the available information on destruction of the PBDEs in waste incinerators. In Denmark, BFR-containing plastics are currently incinerated in MSW incinerators equipped with filters for control of emissions of dioxins. The available information indicates a destruction efficiency of better than 99.999%. One of the actions of the updated NIP for the Stockholm Convention was to encourage the European Commission to prepare a study to validate whether technical pentaBDE is sufficiently destroyed in ordinary waste incinerators. In an email to the Danish EPA of 21 June 2013, the European Commission stated that according to the experts the European Commission consulted, it appeared that PBDEs could be incinerated in MSW incinerators, if necessary measures were taken to secure that the bromine concentration is not excessive. The updated NIP for the EU (European Commission, 2014) does not specifically address the issue and no new studies have been undertaken.

The guidance on BAT/BEP[19] for recycling and disposal of PBDEs listed under the Stockholm Convention (2017b) states that BAT incineration facilities are able to cope with the addition of POP-PBDE-containing polymers. Any resulting levels of unintentionally formed chlorinated, brominated and brominated-chlorinated dioxins (PXDD/PXDF) formed in the first combustion stage could then be destroyed in the secondary combustion zone operated according to BAT (sufficient residence time (2 seconds), temperature control (≥850ºC) and turbulence with appropriate design. Furthermore, it was noted that in state-of-the-art waste incineration facilities equipped with dioxin abatement measures for compliance with stringent emission limits for PCDD/F (0.1 ng I-TEQ/Nm^3), it may be assumed that PXDD/PXDF are also adequately captured.

In a desktop study on destruction of persistent organic compounds in combustion systems by Umeå University for the Swedish Environmental Protection Agency, Lundin and Jansson (2017) conclude that PBDE is destroyed in MSW incinerators operated with a temperature of ≥850ºC but note that the confidence level is low because of the limited number of studies available.

2.3.10.2 Possible separation of household waste containing pentaBDE

As PBDE is considered to be effectively destroyed in MSW incinerators used in Denmark, no further studies on the separation of household waste containing pentaBDE or other PBDEs have been undertaken.

2.3.10.3 Guidelines concerning non-recyclable mixtures and articles containing pentaBDE

No guidelines concerning non-recyclable mixtures and articles containing pentaBDE have been developed. According to the data presented in the previous NIP from 2012, all articles containing pentaBDE were expected to be disposed of by 2016. Consequently, actions regarding non-recyclable mixtures and articles containing pentaBDE were not considered relevant anymore.

2.3.10.4 Examine the possibilities of identifying pentaBDE in shredder waste

In a study on hazardous substances in shredder residues, Hyks *et al.* (2014) note that limited information is available on brominated flame retardants in shredder residue. The study summarises results of analyses of brominated flame retardants in three samples of shredder waste produced at a Danish shredder plant in 2012. Many of the PBDE congeners were below the detection limit. PentaBDE, measured as the sum of the three congeners of BDE#47, BDE#99 and BDE#100, were highest in the “heavy” shredder fraction of particle size 0-100 mm, where a concentration of 80 mg/kg was measured. In the light fractions, the concentration was <10 mg/kg. For octaBDE and decaBDE, the concentrations were below the detection limits of 50 and 100 mg/kg, respectively. The concentrations were far below the limit concentration for the sum of the listed PBDEs of 10,000 mg/kg (see appendix 1). Regarding analyses of brominated flame retardants, the authors note that results for the light fractions were comparable with Norwegian data, whereas results for the heavy fraction were somewhat higher. The study

[19] BAT; Best Available Techniques. BEP: Best Environmental Practice

concludes that concentrations of brominated flame retardants in the waste are not of concern with regard to resource recovery of shredder waste.

In its guidelines for classification of shredder waste as hazardous or non-hazardous waste, the Danish EPA recommends analysing the waste for a number of substances on the basis of studies on hazardous substances in shredder waste. Of these, PCB is the only substance listed under the Stockholm Convention (Danish EPA, 2015b).

2.3.10.5 HexaBB and PBDE in food

No recent data on hexaBB and PBDE in food in Denmark are available; hexaBB and PBDEs are not included in the reviews of the 2004-2011 and 2012-2014 food monitoring data (Petersen *et al.*, 2015a; Petersen *et al.*, 2015b).

The previous NIP from 2012 noted that concentrations in all food samples from 2009 and 2010 were just below the recommended tolerance level of 100 ng/g fat determined by the Danish Veterinary and Food Administration.

2.3.10.6 Total human exposure

The European Food Safety Authority's (EFSA) Scientific Opinion on PBDEs in Food concluded that for BDE#47, BDE#153 and BDE#209, current dietary exposure in the EU does not raise a health concern. For BDE#99 (main constituent of pentaBDE), there is a potential health concern with respect to current dietary exposure (EFSA, 2011). The opinion does not include an assessment of combined exposure to PBDE, but it is noted in the uncertainty assessment that the possibility of combined effects of different PBDE congeners may lead to an underestimation of the exposure/risk (EFSA, 2011).

Total dietary exposure in Denmark to BDE#99 was slightly below the median value for European countries (EFSA, 2011); i.e. the conclusions regarding health risk mentioned above may also apply to Denmark.

Kortenkamp *et al.* (2017) recently performed an analysis of the combined exposure to a number of PBDEs and discuss the EFSA conclusions. The analysis suggests that combined exposures to PBDEs may exceed acceptable levels in breastfeeding infants (0–3 months old) and in small children (1–3 years old), even for moderate (vs. high) exposure scenarios. The authors furthermore state that their estimates also suggest that acceptable levels of combined PBDEs may be exceeded in adults whose diets are high in fish. Small children had the highest combined exposures, with some estimated body burdens that were similar to body burdens associated with developmental neurotoxicity in rodents (Kortenkamp *et al.*, 2017).

2.3.10.7 PBDE and hexaBB in the environment

In the Danish marine coastal waters, DCE (2016b) found PBDE in all samples of marine fish species taken during the annual NOVANA monitoring. In all samples, the EQS of 8.5 ng/kg ww (muscle) was exceeded. The PBDE content in fish muscle was 16-37 times higher than the EQS and the authors therefore concluded that this substance group may have a significant influence on the state of the environment. PBCDs have not been monitored in any environmental matrices other than marine biota under the current NOVANA monitoring programme since the last NIP.

PBDEs (and hexaBB) are not included in the Danish groundwater surveillance programme, GRUMO.

2.3.11 Unintentional formation of dioxins and other POPs listed in Annex C to the Convention

The previous NIP listed three actions to be taken for unintentional formation of POPs:

- Improve emissions inventories for PCB, HCB and pentachlorobenzene
- Monitor developments in relation to releases of POPs from wood-burning stoves
- Develop further technologies for treatment of flue-gas cleaning products.

Currently Annex C to the Convention and Annex III to the POP Protocol include the following substances: Dioxins (PCDD/PCDF), PCB, HCB, pentachlorobenzene, HCBD and PCNs.

2.3.11.1 Emissions of dioxins (PCDD/PCDF)

Emissions of dioxins, PCB and HCB are reported as part of the reporting for the UNECE Convention on Long-range Transboundary Air Pollution, LRTAP (Nielsen *et al.*, 2018).

The time trend in emissions for the period 1990 to 2016 is shown in the figure below. In the 1990s, energy industries (mainly municipal waste incinerators) constituted the major source. However, this source decreased markedly because of implemention of improved flue gas cleaning systems and, since 2005, has been stable at about 1 g I-TEQ/y. The emission of dioxins from energy industries (5% in 2016) is dominated by combustion of biomass as wood, wood waste and, to a lesser extent, agricultural waste (mainly straw).

Emissions from wood stoves, pellet boilers and other residential heating systems (the majority of "non-industrial combustion" in the figure), increased during this period and accounted for 13.0 g I-TEQ of the total of 22 g I-TEQ in 2016. Wood combustion in residential heating systems accounted for 59% of national dioxin emissions in 2016. The inventory uses differentiated emission factors for old and new wood stoves. For old and "new" stoves, the emission factor is 800 ng I-TEQ /GJ, whereas it is 250 ng I-TEQ /GJ for a modern stove and 100 ng I-TEQ /GJ for a modern ecolabelled stove (Nielsen *et al.*, 2018). As the older stoves are gradually replaced with modern stoves, total emissions are expected to decrease.

The contribution to total dioxin emission from the other sectors (26% in 2016) is mainly attributed to accidental fires, especially building fires. The total emission from fires is estimated at 5.8 g I-TEQ and has been relatively stable over the period 1990-2016.

The emission of dioxins from MSW incinerators is estimated on the basis of measurements under normal, stable conditions and may underestimate actual total emissions. The most recent Danish substance flow analysis for dioxins (Hansen, and Hansen, 2003) notes that higher emissions under deviating process conditions may significantly add to total emissions and the study calls for more information on this issue. It is expected that the revised BAT Reference Document to be published in 2020 will include requirements for continous sampling of dioxins (as opposed to the current 6-hour sampling) and that the basis for quantification of total emission from the plants will be significantly improved.

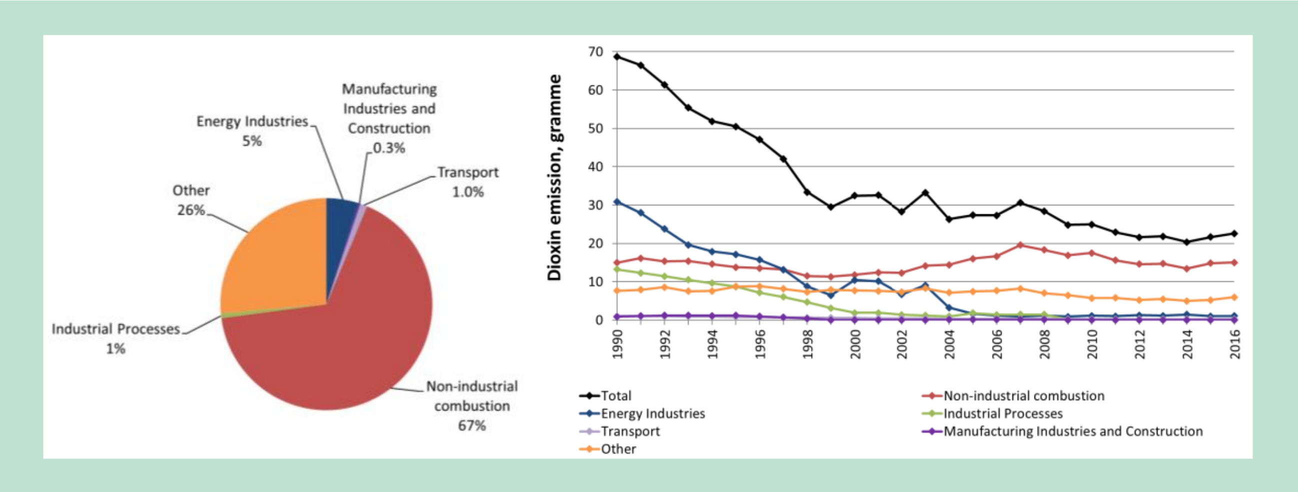

FIGURE 5. Emissions of dioxins (PCDD/PCDF) by main sectors (2016) and time series for 1990 to 2016 (Nielsen *et al.*, 2018 reproduced courtesy of DCE). Emission in g I-TEQ.

2.3.11.2 Unintentional formation and emissions of HCB

A detailed national emission inventory is available for emissions of HCB. Total emission to air in 2016 was 2.3 kg. The total emission has decreased from about 45 kg in 1991 and about 10 kg in 1994.

Stationary combustion accounted for 56% of the estimated national HCB emission in 2016. The majority is due to MSW incinerators. Transport made up 32% of total emissions in 2016. HCB emissions from stationary plants have decreased 78% since 1990 mainly because of improved flue gas cleaning in MSW incinerators.

Emissions from transport have increased by 73% since 1990 due to increasing diesel consumption.

The peak emissions from agriculture in the 1990s was because of the use of pesticides containing impurities of HCB. The share of HCB emissions from agriculture decreased from 67% of total emissions in 1990 to 5% in 2016. Emissions from industrial processes decreased due to the closure of steel production and secondary aluminium production in Denmark.

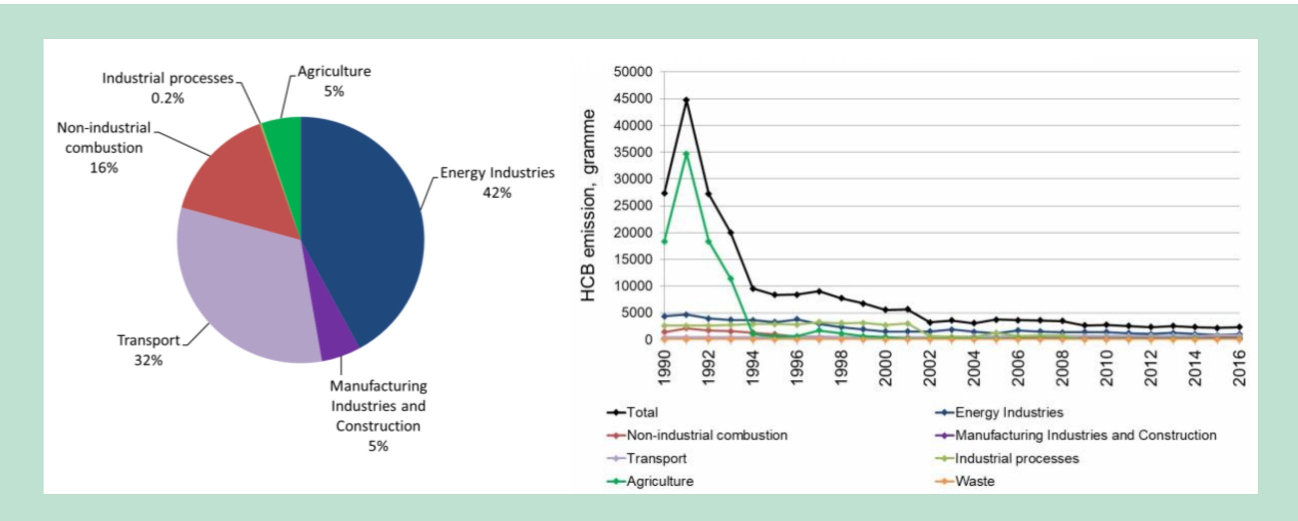

FIGURE 6. Emissions of HCB by main sectors (2016) and time series for 1990 to 2016 (Nielsen *et al.*, 2018 reproduced courtesy of DCE).

2.3.11.3 Unintentional formation and emissions of PCB

PCB may be released due to former intentional use of PCB (e.g. in building materials) and its unintentional formation in combustion and chemical processes. A detailed national emission inventory is available for unintentional formation of PCB. The emission inventory is based on emission factors from the UNECE and represents the dioxin-like PCBs, but it is reported as total content dioxin-like PCB congeners, which is not recalculated into dioxins equivalence (WHO-TEQ). The inventory does not include emissions to the environment from remaining PCB in building materials and electrical equipment (Nielsen *et al.,* 2014).

Of the released PCB, transport accounts for 70% of estimated national PCB emissions in 2016. The main contribution occurs as a result of combustion of diesel in road transport. The emission from transport has decreased significantly from 1990 to 1994 because of the phase-out of leaded gasoline, which has a high PCB emission factor. The emission from manufacturing industries and non-industrial combustion is dominated by diesel fuel used in non-road machinery (Nielsen *et al.*, 2018).

An inventory from the UK estimates both dioxin emission and dioxin-like PCB emission in WHO-TEQ and compares the emission of dioxins with the emission of dioxin-like PCB (Conolly *et al.*, 2009). Total dioxin emission to air in 2006 was estimated at 270 g WHO-TEQ while the total emission of dioxin-like PCB was estimated at 360 g WHO-TEQ, i.e. higher than the dioxin emission. Open burning of waste and accidental fires were the largest source, accounting for 240 of the 360 g WHO-TEQ, with the power industry and iron and steel contributing 49 and 43 g WHO-TEQ, respectively. Emissions of dioxin-like PCB to water and land were not estimated. Total PCB releases to air were estimated at 5 t/year, mainly from transformers and capacitors (4.1 t/year), while releases to land were estimated at 1.6 t/year (1.3 t/year from transformers and capacitors) and releases to waste at 0.08 t/year from WWTPs.

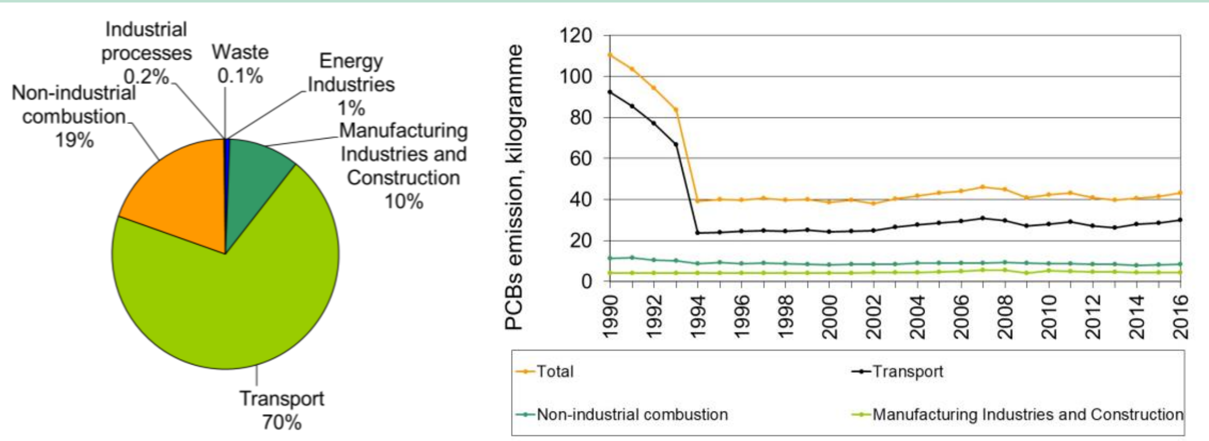

FIGURE 7. Emissions of unintentionally formed dioxin-like PCB by main sector (2016) and time series for 1990 to 2016 (Nielsen *et al.*, 2018, reproduced courtesy of DCE). The unit is total weight of dioxin-like PCB in kg, not recalculated into WHO-TEQ.

2.3.11.4 Formation of pentachlorobenzene, HCBD and PCNs

The national emission inventories for the UNECE do not include pentachlorobenzene, which is not listed under the UNECE POP protocol. The emission inventories, furthermore, do not include HCBD and polychlorinated naphthalenes (PCNs) which have been listed under the POP Protocol but are not yet in force. No emission factors are available for the substances from the

EMEP/EEA inventory guidebook for emission inventories undertaken as part of the reporting under the United Nations Economic Commission for Europe (UNECE) (EMEP/EEA, 2016).

The national inventory for 2014 for PCB and HCB also included a screening for pentachlorobenzene with the conclusion "*The screening for emission sources for pentachlorobenzene (PeCB) showed that the available data are extremely limited and in many cases the reported data are based on highly uncertain assumptions. While it can be assumed that emissions of PeCB can occur from the same sources as HCB, very few measurements have been reported in the literature."* (Nielsen *et al.*, 2014). As a consequence of the limited data, national emissions inventories for pentachlorobenzene are not undertaken.

No data on the unintentional production of HCBD in Denmark are available. As the industrial processes considered the main sources of unintentional formation of HCBD do not take place in Denmark, the emissions are considered likely to be small.

No data on the unintentional production of PCNs in Denmark are available. PCNs are known to be formed in thermal processes, of which waste incineration is the most important (van der Plasshe and Schwegler, 2002). Other thermal processes possibly resulting in PCNs emissions are copper ore roasting, aluminium reclamation and the chlor-alkali industry (van der Plasshe and Schwegler, 2002). None of these processes takes place in Denmark.

2.3.11.5 Improvement of wood stoves and other residential combustion sources

As shown above, combustion of wood in wood stoves accounts for more than half of the total emission of dioxins, whereas wood stoves are considered of minor importance as to the releases of PCB and HCB.

The last NIP reviewed studies of emissions from wood-burning stoves, which have shown large variations in emissions of dioxins, but no clear answers to whether there is any correspondence between the magnitude of emissions, on the one hand, and on the other hand, type of installation, firewood and consumer habits. Similarly, the studies did not demonstrate any clear correspondence between emissions of dioxin and emissions of PAH and particles. Efficient combustion with excess oxygen and high temperatures promote the formation of dioxins, but minimise the emission of PAH and particles. Emission of PAH and particles from wood stoves are considered of major importance. DCE has estimated that, annually, 550 people die before they normally would as a consequence of exposure to particles from wood stoves (DCE, 2016a).

As mentioned above, the national emission inventory uses differentiated emission factors for old and new wood stoves derived from the EMEP/EEA (2016) emission guidebook. For old and "new" stoves, the emission factor is 800 ng I-TEQ/GJ, whereas it is 250 ng I-TEQ/GJ for a modern stove and 100 ng I-TEQ/GJ for a modern ecolabelled stove (Nielsen *et al.*, 2018).

The development in the number of stoves in use is shown in the table below. In 2016, stoves with high emission factors of 800 ng I-TEQ/GJ still constituted 62% of the total number of units, and thereby also represented the majority of dioxin emissions.

TABLE 21. Trend in number of units of stoves in Denmark (Nielsen *et al.*, 2018). Please note that the table does not includes data on small boilers which would contribute to total emission from small combustion units.

	Number of units					% of total in 2016	Emission factor ng I-TEQ /GJ
Type	2000	2005	2010	2015	2016		
Old or new stoves	671,917	651,422	518,927	418,932	398,933	55%	800
Modern stoves	-	22,500	56,000	66,000	68,000	9%	250
Eco-labelled stoves	-	-	99,000	189,000	207,000	29%	100
Other stoves *	48,725	48,725	48,725	48,725	48,725	7%	800
Total stoves	720,642	722,647	722,652	722,657	722,658	100%	

* Category consists mainly of open fireplaces and masonry stoves

The emission factors for the least polluting stoves in the EMEP/EEA (2016) guidebook are derived from a Swedish study of Hedman *et al.* (2006). According to the study, a modern, eco-labelled boiler yielded somewhat lower emissions of dioxins and PCB than a wood stove. The stack concentration from both the boiler and the wood stove was measured at <0.1 ng WHO-TEQ/Nm^3. The measured emission factors were 1.3−6.5 ng WHO-TEQ/kg wood (corresponding to approximately 100 to 300 ng WHO-TEQ/GJ) and considerably lower than the measured emission from an old boiler (7.0−13 ng WHO-TEQ/kg wood).

Two recent Danish studies found higher mean emission factors for modern wood stoves.

Andersen and Hvidbjerg (2017) have measured emissions of dioxins and other pollutants from four modern wood stoves on the Danish market. The four stoves were all Swan eco-labelled when introduced to the market, but they were not eco-labelled at the time of measuring even though the quality of the stoves was the same (Andersen and Hvidbjerg, 2017). The stoves consequently should be identical to those indicated in the national emission inventories as "Eco-labelled stoves". The reason for changing the ecolabel status is not described. When using untreated birch firewood, the measured dioxin levels were at about 700 ng I-TEQ/GJ, well above the EMEP/EEA (2016) emission factors for modern wood stoves of 250 ng I-TEQ/GJ and the emission factor for eco-labelled wood stoves of 100 ng I-TEQ. The study concludes that whereas it may be reasonable to expect decreased total emission of particulate matter and organic gaseous compounds as the wood stoves become newer and better, it seems unjustified to expect a similar decrease for dioxin emission (Andersen and Hvidbjerg, 2017).

When salt was added to the birch firewood, the emissions increased by a factor of 16. Schleicher (2018) states in a newer investigation that unrealistically high amounts of salt were added, but also notes that their results confirmed other results demonstrating higher dioxin emission because of higher chlorine concentration of the firewood.

Andersen and Hvidbjerg (2017) note that it has been demonstrated to be essential in power plants to quickly cool down the flue gas to less than 200˚C in order to reduce the formation of dioxins in the flue gas duct. This may explain why measurement of a specific wood stove in the beginning of the 1990s in Denmark found emissions of a level of less than 1/10th that of the emission of dioxins measured from modern stoves. The explanation may be that the stove was equipped with a water heating system which resulted in quick cooling of the flue gas.

Schleicher (2018) measured *in situ* emissions from wood stoves in eight Danish houses. All houses have new wood stoves (2008 or newer) and all users applied fairly good burning techniques. In addition to the eight houses emission was measured from one house where the used burning conditions apparently resulted in incomplete combustion.

The measurements showed high variability with emissions ranging from 4 ng I-TEQ/GJ to 3,795 ng I-TEQ/GJ with a mean value of 1,839 ng I-TEQ/GJ, i.e. the mean factor is about 7 times the emission factor of 250 ng I-TEQ/GJ for modern stoves. The author notes that the mean value is slightly higher than the mean factors measured in two previous projects with *in situ* measurements (the Gundsømagle projects).

The mean value is very much dependent on a few measurements of very high concentrations. Of the nine stoves, three (including the one with bad burning techniques) had emissions significantly above the 250 ng I-TEQ/GJ. The two highest measured emission factors were from stoves where the users employed good burning techniques.

The author notes that *in situ* measurements generally show higher mean emission factors than laboratory tests, a finding which could be due to other qualities of the firewood used. In laboratory tests, standardised firewood of a high quality is used, whereas the firewood used in households may have higher natural contents of chlorine or may have been contaminated by chlorine and copper compounds. These may lead to higher generation and emission of dioxins. The highest emission factors were measured from stoves where the firewood was from local gardens and parks. The author suggests it would be relevant to investigate further whether firewood from Denmark contains higher concentrations of chlorine than imported firewood and to what extent this would result in higher dioxin emissions.

Both studies indicate that the emissions are highly dependent on the firewood used and the investigations do not confirm that use of newer, ecolabelled woodstoves generally should result in significantly lower emissions of dioxins. The authors of the studies call for more investigations into the importance of the chlorine and copper content of the firewood and the importance of rapid cooling of the flue gas. As part of the stakeholder consultation, an older Danish study has been mentioned which found that the dioxin emissions using firewood without bark were lower (50%) than the emissions using firewood with bark (Schleicher *et al.*, 2001). The explanation may be that the growth layer just below the bark has a high content of trace elements, salts and more complex organic compounds (Schleicher *et al.*, 2001).

The Danish Statutory Order on wood stoves - "Brændeovnsbekendtgørelsen" from 2008 (most recent version BEK no 49 of 6/01/2018) - has some requirements as to the emissions of particles and other pollutants, but no requirements regarding emission of dioxins. At EU level, the ecodesign requirement for domestic biomass appliances will come into force on 1 January 2022 (EU Regulation 2015/1185) with requirements quite similar to the existing Danish requirements.

Because of the health effects particularly of fine particle emissions from wood stoves, a tax on wood stoves was considered by the Danish Government in 2017, but the political majority of the Parliament is against a tax and indicates improved wood stove technology as the better solution. The newest investigations do not support an assumption that improved wood stove technology would result in lower emissions of dioxins.

2.3.11.6 Dioxins in residues from waste incineration

During flue-gas cleaning, a large proportion of the dioxins formed will end up in the flue-gas cleaning products. Furthermore, the flue-gas cleaning products may contain non-destroyed PCB. One of the actions of the previous NIP from 2012 addressed further development of technologies for treatment of flue gas cleaning products.

By far the majority of flue-gas cleaning products are exported to Norway or Germany. In Norway, the residual products are mixed with acid-containing wastes (e.g. sulphuric acid) and hydrated lime, whereby the residual products are neutralised and stabilised. The resulting plaster is used to fill a former limestone quarry on the island of Langøya in the Oslo fjord. In Germany, the residues are mixed with a series of added materials to form a concrete-like mass, which is built into old salt mines.

With funds from EU's financial instrument supporting environmental, nature conservation and climate action projects, an ongoing project, LIFE HALOSEP, was undertaken in cooperation between the Swedish company Stena Recycling A/S and the Danish MSW incinerator I/S Vestforbrænding (Stena Recycling, 2016). The main objectives of the project were to demonstrate that two waste streams from incineration plants, fly ash and scrubber liquid, can be co-treated leading to a reduction of waste going to landfills and increased material recycling and that the patented Halosep process can be installed and integrated into an existing waste incineration plant. The project runs until the end of 2019.

2.3.11.7 Dioxins in sludge

No data on dioxins in sewage sludge disposed of in Denmark are available. According to the investigation by Bagge (2012), in most of the 108 samples of sludge from Danish food processing industries analysed for dioxins, the level was below 10 ng TEQ/kg and in all samples the concentration was below the German limit value of 100 ng TEQ/kg.

2.3.11.8 Dioxins and dioxin-like PCBs in food and animal feed

The content of dioxins and dioxin-like PCBs in food and animal feed is subject to regular monitoring by the Danish Veterinary and Food Administration. The monitoring programme includes a number of food items with relatively high risk of significant content, such as meat from third countries, dairy products, fish and fish products, eggs, vegetable fat for production and dried herbs. Maximum levels and action levels for dioxin and dioxin-like PCB have been established at EU level (Regulation (EC) No 1881/2006 as amended).

The most recent monitoring results of fish (excluding herring and salmon which are monitored separately) for 2016 demonstrated concentrations above the maximum value in some samples of mackerel and cod liver from the Baltic Sea (DFVA, 2016 a).

It has been found that eggs from free-range hens that have access to debris in soil may have higher contents of dioxins. The hens probably take up dioxins from the soil they peck in, or from larvae and insects in the soil. The DVFA is in a process of mapping out whether there are geographical or other factors that play a role. However, preliminary results do not indicate that there are geographical conditions that play a role (DFVA, 2016d). Another factor to be included is the size of the chicken stock as higher concentrations are generally found in smaller stocks. The 2015/2016 monitoring programme included 56 stocks. Samples from six of the stocks exceeded the maximum value for dioxins while samples from one stock exceeded the maximum value for PCBs but the exceedance was not significant. Further investigations demonstrated that the sources of dioxins and PCB probably were different and in some of the stocks originated from the henhouse materials, whereas in others, the concentration of dioxins and PCB in the soil was relatively high. Based on previous monitoring results demonstrating similarly high levels in eggs from free-range hens, the DVFA along with the Danish egg producers issued a guidance document with possible measures to be taken in order to reduce the level of dioxins and PCB in eggs (DVFA, 2013a). The DVFA concludes that the majority of eggs comply with the limit values and that there is generally no health risk from eating eggs from free-range hens, either organic or conventional. The DVFA recommends that consumers if they buy local eggs from free-range hens, buy eggs from different stocks and supplement with eggs from the supermarket. The agency also recommends that consumers with own stocks of free-range hens supplement with eggs from supermarkets.

Monitoring results of other food items generally found concentrations below the maximum action levels but one sample of horse meat exceeded the limit value (DVFA, 2016b). In general, horse meat contains relatively high levels of dioxins and dioxin-like PCB; the DVFA recommends not eating horse meat more than once a week.

The 2012-2013 review describes a follow up project on wild salmon from the Baltic Sea (Petersen *et al.*, 2015). The levels of dioxins and PCB in Baltic salmon do not comply with the maximum levels, but Danish studies have shown that intensively trimming fat from the salmon fillet reduced the levels of dioxins and PCB. The study showed that fat trimming reduces the levels of dioxins and PCB significantly, but trimmed fillets from salmon with a weight of approximately 5.5 kg still exceeded the maximum level (Petersen *et al.*, 2015). Monitoring data from 2006, 2011 and 2013 show the same level in 2006 and 2013, whereas lower levels were found in 2011. The lower level in 2011 is correlated with lower concentrations of fat in the salmon, which may explain the lower dioxins level that year. A Danish Statutory Order (most recent version BEK no 1487 of 05/12/2016) makes it possible to sell fillets of Baltic salmon provided that the fillet is trimmed and originates from a salmon weighing a maximum of 5.5 kg.

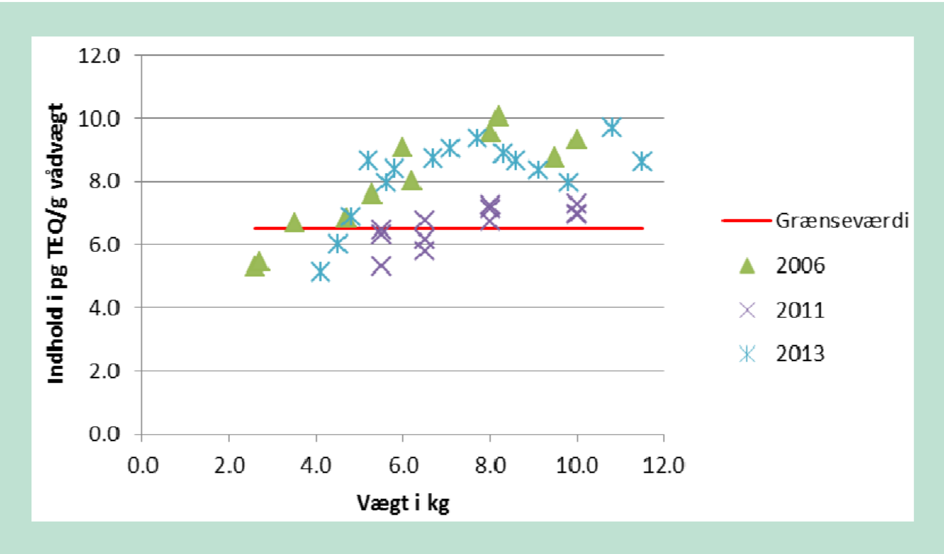

FIGURE 8. Sum of dioxins and dioxin-like PCB in trimmed salmon from the Baltic Sea in 2006 (n=11), 2011 (n=12) and 2013 (n=15). Concentrations in pg WHO-TEQ$_{2005}$/g wet weight (DVFA, 2013b). Red line is the limit value.

Dietary exposure. The 2004-2011 review includes an estimate of total dietary exposure to dioxins (Petersen *et al.*, 2015a). The mean exposure to dioxins and dioxin-like PCB was 0.55 pg WHO$_{2005}$-TEQ/kg bw/day in the 95th percentile (the 5% with highest intake) of 1.2 pg WHO$_{2005}$ TEQ/kg bw/day. The corresponding exposure mean value for children aged 4 to 14 was 0.87 pg WHO$_{2005}$-TEQ/kg bw/day in the 95th percentile of 1.9 pg WHO-TEQ/kg bw/day. The assessment concludes that dietary exposure to dioxins and dioxin-like PCB exceeded the tolerable weekly intake (TWI) for a small fraction of the population, mainly children. The dietary exposure of about 5% of the children exceed the TWI. The TWI was established by the Scientific Committee on Food (SCF) at 14 pg WHO-TEQ/kg bw/week.

In November 2018, EFSA, the European Food Safe Authority published a new TWI at 2 pg WHO-TEQ/kg bw/week (DTU Food, 2018). According to the National Food Institute, the average TWI of the Danish population is 3.9 pg WHO-TEQ/kg bw/week; consequently, the average exposure of the population is nearly twice the TWI (DTU Food, 2018). There is, however, still some uncertainty regarding the toxicity of one of the important PCB congener which has influence on the assessment.

As consequency of the lower TWI, the Danish Food Agency has changed the recommendations to consumers.

The dietary exposure is mainly from fish (31% of total), dairy products and meat, while eggs and poultry contribute less than 5% (Petersen *et al.*, 2015a). The assessment does not indicate the importance of exposures other than dietary. More than 90% of general human exposure to dioxins and dioxin-like PCBs is estimated to occur through the diet (Larsen and Nørhede, 2013).

The assessment does not indicate the distribution in terms of TEQ between dioxin-like PCB and the dioxins. Monitoring results for fish show that the dioxin-like PCB TEQ exceeds the dioxins TEQ in most cases, whereas dioxin-like PCB TEQ is typically lower than the dioxins TEQ in other food items.

According to the first NIP for the Stockholm Convention from 2006, the mean intake of dioxins and dioxin-like PCB by Danish adults was calculated in the range 0.8-1.1 pg WHO-TEQ/kg bw/day (recalculated here from the weekly intake). Average values for the 5% of Danes with the highest intake (95th percentile) were between 1.8 and 3.7 pg WHO-TEQ/kg bw/day. The data indicate a decreasing trend in dietary exposure to these substances. This is in accordance with a general decreasing trend in the EU; EFSA (2012) demonstrates a general decrease in dietary exposure to dioxins and dioxin-like PCBs, comparing the period 2008-2010 with 2002-2004, of at least 16% and up to 79% for the general population, with a similar decrease for toddlers and other children.

2.3.11.9 Dioxins in breast milk

Dioxins in breast milk in Denmark have been reviewed in the previous NIPs. A recent study on the country-specific chemical signatures of persistent organic pollutants (POPs) in breast milk of French, Danish and Finnish women found that the observed exposure levels of dioxins and dioxin-like PCBs were higher in Danish women (sum: 19.8 pg WHO_{2005}-TEQ /g l.w.) compared to Finnish (13 pg WHO_{2005}-TEQ /g l.w) and French women (10.5 pg WHO_{2005}-TEQ /g l.w) (Antignac *et al.*, 2016). As the concentration is decreasing, the comparison is highly sensitive to the years the particular investigations compared were carried out. The samples from France were from 2011-2014, whereas samples from Denmark and Finland were from 1997-2002; the data consequently cannot be directly compared. Furthermore, the background data indicate that differences between Denmark and Finland were not significant. Krysiak-Baltyn at al. (2010) have previously demonstrated that Danes generally have higher exposure to POPs than Finns, indicating higher exposure levels to POPs in Denmark.

Wohlfahrt-Veje *et al.* (2016) investigated whether early exposure of healthy infants to dioxin-like chemicals was associated with changes in early childhood growth and serum IGF1 (Insulin-like growth factor 1). Based on 418 maternal breast milk samples from mothers of Danish children (born 1997-2001), it was found that environmental exposure to dioxin-like chemicals was associated with low birth weight and with higher infant levels of circulating IGF1 as well as accelerated early childhood growth (rapid catch-up growth).

2.3.11.10 Dioxins in the environment

Limited new data on the emission of dioxins to the environment and on the current levels of these substances in environmental compartments have been generated since the previous NIP.

According to the first NIP for the Stockholm Convention from 2006, of the amounts of dioxins deposited in Denmark in 2003, more than half came from Danish sources, whereas 8% came from the United Kingdom, and seven and four percent, respectively, came from Germany and Poland. More recent figures have not been identified. Newer detailed studies of the sources of dioxins in the atmosphere in Denmark have not identified.

A modelling of sources of dioxins deposited in the Baltic Sea region have estimated the sources of dioxins (using the congener 2,3,4,7,8-PeCDF as indicator) to the different sub-basins of the Baltic Sea (Shatalov *et al.*, 2012). The contribution from Danish sources accounted for 49% og the deposition flux to the Belt Sea and 41% of the deposition flux to the Kattegat. The contribution from countries outside the Baltic Region was 24% of the flux to the Belt Sea and 27% of the flux to the Kattegat. For the other sub-basins, the contribution from Danish sources was low.

A study from 2016 on risk of cancer as consequence of air pollution in the Nordic Countries notes that regional (as opposed to national) sources are the main sources of dioxins in rural (92%) and urban background sites (88%) in Denmark (Fauser *et al.*, 2016).

As part of the Baltic POP project Wiberg *et al.* (2013) studied the dioxin issue in the Baltic region focusing on sources to air and fish. Levels of PCDD/Fs in the air were generally found to be below the limit of detection during the summer season (1 fg TEQ /m³) while in the winter season, the average level was 6.0 fg TEQ/m³. The atmospheric transport model estimated that the origin of PCDD/Fs in Baltic air is mainly from continental Europe. According to the authors, the higher PCDD/F concentrations during winter season and the mostly non-quantifiable concentrations during summer season indicate that primary emission sources of PCDD/Fs rather than temperature-driven re-volatilisation from soils (secondary emissions) control dioxin levels in air. Furthermore, the authors conclude that the high dioxin levels during the winter season indicate a dominance of non-industry-related combustion sources, presuming that there is no seasonal trend in industrial production (Wiberg *et al.*, 2013). However, the dioxins and metal data could not be used to pinpoint one combustion source category as more important than others. Regarding the sources of dioxins in herring, the project confirmed the conclusions of previous work that the atmosphere is, and will continue to be, the major external source of dioxin pollution in the Baltic Sea and thus dioxin contamination in herring populations (Wiberg *et al.*, 2013). The study did not assess how much of the current level of dioxins in herring could be attributed to remobilisation of dioxins from the sediment due to former emissions of dioxins.

In contrast to the air concentrations of dioxins, PCBs in Baltic air were significantly higher during summer than winter. This indicates that emissions from secondary sources, such as volatilisation from buildings and waste sites during the warm summer season, are of significant importance for PCBs (Wiberg *et al.*, 2013).

In a recent study by Assefa *et al.* (2018) it was found that the thermal sources have been, and still are, the major source type contributing to dioxins in Baltic herring. The thermal source type contributed most to the dioxins in the herring during the studied periods (72% for pre-2000 and 59% in post-2000 periods, as an average for all three studied basins). The study concludes that the declining impact of the thermal source type in Baltic herring, as well as in sediment and air, is a good indicator that previous actions have been effective in reducing dioxin levels in Baltic Sea ecosystems. Still, the continued major impact of thermal sources motivates continuous efforts to manage these emissions (Assefa *et al.*, 2018). The relative importance of the thermal source type has declined since 2000, while tetrachlorophenol (TCP) and pentachlorophenol (PCP) related sources as well as atmospheric background (AB) sources have increased in relative importance. This means that for the water and biota compartments, the dispersal of dioxins from the sediments are becoming increasingly important over time, and that the sediment thus functions as a secondary source of pollutant sources (Assefa *et al.*, 2018). The contribution of dioxins mobilised from the sediment to the total dioxin content of the herring was not quantified.

HELCOM (2018b) found that the levels of dioxins and dioxin-like PCBs in fish in the Baltic Sea in most places are below the WHO threshold value of 0.0065 µg TEQ/kg ww, with exceptions in the northernmost part of the Bothnian Bay and at four locations in the inner Danish marine waters (three fjords/bays and the Kattegat).

NOVANA data published by DCE (2016b, 2018) show that the contents of dioxins in fish and mussels sampled at the NOVANA monitoring stations in all cases were below the WHO threshold value (EQS) of 0.0065 µg TEQ/kg ww. The highest level was found in mussels from Roskilde Fjord, at about 10% of the WHO threshold value.

In sediments from the inner Danish marine waters, the level of dioxins and dioxin-like PCBs were in the range 0.25-7.1 ng TEQ/kg dw with a median value of 2.9 ng TEQ/kg dw (all values normalised to 2.5 % TOC, total organic carbon). Samples from three locations (Aarhus Bugt, Lillebælt and Øresund) were two-three times higher than the median value (DCE, 2016b).

2.3.12 Stockpiles, waste and contaminated sites

2.3.12.1 Stockpiles

No stockpiles of obsolete POPs pesticides exist in Denmark.

No other stockpiles of the substances on their own in Denmark have been identified.
Of the six newly added POPs, some stocks of the substances are accumulated in articles used in society and building materials:

- **DecaBDE** is to some extent accumulated in society in electrical and electronic equipment (EEE), vehicles and other means of transport, and building materials. In 1997, the total consumption of PBDEs was 30-120 t/y; of this, the majority was decaBDE. The consumption likely continued at this level until the use of the substances was restricted in EEE in 2008, but after this time, the substances were still used for some other applications. The average lifetime of most EEE is 10-15 years and it is roughly estimated that the quantities accumulated in society are in the range of 100-500 tonnes.
- **HBCDD** has been used until recently in EPS/XPS for building and construction applications, textiles and transportation. The majority accumulated in society is considered to be in EPS/XPS for building materials as these materials have average lifetimes well above 30 years. In 1999, the consumption for building applications was 13 - 36 t/year; likely, consumption has stayed this level for decades. Assuming that HBCDD has been accumulated in building and construction for about 30 years, the total accumulated in this sector could likely be 400 - 1000 tonnes. Compared to this, the quantities accumulated in EEE; means of transportation and textiles are considered to be low. This supposition is in accordance with the general situation in the EU (ESWI, 2011).
- **SCCPs** are initially accumulated in building materials and rubber products containing the substances. The quantity disposed of annually is estimated at about 7 t/year and is steeply declining. The total quantity still accumulated in society is likely in the 20-100 tonnes range.
- **PCP** may be accumulated in society in wood preserved with PCP. The amount of PCP-treated wood still in use is estimated to be very low. The amount of PCP-treated wood still in use in Denmark in 2000 was assumed to correspond to an initial PCP quantity of approximately 680 tonnes by Hansen and Hansen (2004); the authors estimate that the quantity

had decreased to 430 tonnes in 2003.The steep decline is expected to have continued for a number of years, but the decline may have levelled out. Considering the estimated amounts accumulated in the EU (ESWI, 2011), the amount accumulated in society in Denmark today is likely in the 1-10 tonnes range.

- The quantities of **HCBD** and **PCN** accumulated in the society in Denmark is estimated to be insignificant.

Of the other POPs, accumulation in society is first of all an issue for PCB which is described in section 2.3.8.

2.3.12.2 The newly added POPs in solid waste

Information on amounts and sources of the newly added POPs in waste is provided in the waste sections for each of the substances.

2.3.12.3 Incineration of POPs in MSW incinerators

The POP Regulation stipulates that POP waste should be disposed of in such a way as to ensure that the persistent organic pollutant content is destroyed or irreversibly transformed so that the remaining waste and releases do not exhibit the characteristics of POPs. Destruction efficiency is not indicated. The requirements apply to wastes with concentrations above a substance-specific limit value. For PCB this is 50 mg/kg. The Basel Convention general guidelines for POPs (used under the Stockholm Convention) states that for waste with PCB_{total} content above 50 mg/kg, a minimum destruction efficiency of 99.999%, with 99.9999% efficiency for the sum of destruction and removal (i.e. including capture in flue gas residues), as a supplement requirement where applicable, provides practical benchmark parameters for assessing disposal technology performance (Basel, 2017).

The Danish MSW incineration plants operate under conditions given in the Statutory Order regulating waste combustion plants (Statutory Order no. 1271 of 21-11-2017), which include requirements to post-combustion temperature and holding times set at 850 ºC for a minimum of 2 seconds. For plants incinerating hazardous waste with more than 1% halogen, a temperature of at least 1,100 ºC for at least 2 seconds is required.

In Denmark, in total 30 waste incinerators and 5 industrial plants with co-incineration were in operation in 2017. Ot these, two incinerators have a permit for destruction of POPs-containing hazardous waste. The two incinerators are dedicated to destruction of hazardous waste and otherwise problematic waste. One of the incinerators incinerations always keep a temperature of the afterburner at a minimum of 1,100 °C, whereas the other incinerator increases the temperature from 850 to 1,100 °C when waste with a PCB concentration og >50 mg/kg. These two incinerators incinerate more than 10 tonnes of waste per day and are consequently covered by the IE-Direktive. Some of the other incinerators and industrial plants with co-combustion have a permit for incineration of certain types of hazardous waste, but with a content of POPs below the limit values defined by the POPs Regulation.

Apart from waste with PCB, which has been in focus for many years, some articles disposed of for incineration may contain SCCP, PBDEs, HBCDD and PFOS in concentrations above the limit values of the POP Regulation.

In order to further evaluate the destruction of POPs in Danish waste incinerators, the Danish EPA is currently undertaking a desk study on destruction efficiencies for SCCP, PBDEs, HBCDD and PFOS.

The current international knowledge about destruction efficiencies for a number of POPs in MSW incineration plants (ASWI), dedicated hazardous waste incinerations plants (HWI) and rotary cement kilns has recently been reviewed by Lundin and Jansson (2017). The review includes the POP substances PBDE, HBCDD and PFOS as well as the unintentionally formed PCDD/PCDF. In general, Lundin and Jansson (2017) find that the level of information about destruction efficiencies is too weak to conclude with certainty for any of the substances (except for PCDD/PCDF) that the required destruction efficiency of 99.999% is reached in MSW incinerators. However, the information available all point at a high destruction efficiency under stable operating conditions in state-of-the-art incineration plants.

When the ongoing review of destruction efficiencies is ready, the MFVM will assess whether any changes regarding the specific sorting of POPs-containing waste are needed.

2.3.12.4 POPS in shredder waste

One of the listed actions of the previous NIP was to examine the possibilities for identifying PCBs in shredder waste. Until recently all shredder waste in Denmark was landfilled. It is the intention of the Danish EPA that a large part of the generated shredder waste should be incinerated with energy recovery.

Today, one Danish hazardous waste incinerator has permit to incinerate treated hazardous shredder waste with a PCB_{total} concentration >50 mg/kg whereas three incinerators have permits for incineration of treated hazardous shredder waste with a PCB_{total} concentration <50 mg/kg (i.e. the waste is not classified as hazardous on the basis of the POPs content). Two incinerators have permits to incinerate non-hazardous shredder waste.

Data on PCB in shredder waste has been summarised by the Partnership for Shredder Waste [Da: Partnerskab for shredderaffald] (Hansen *et al.*, 2015). The sum of six indicator congeners in shredder waste directed for landfilling range from 7.1-9.0 mg/kg; no significant differences between the different size fractions was observed. The concentrations are compared to a PCB_{total} limit value of 50 mg/kg for classification of the waste as hazardous. The limit value represents PCB_{total} measured by multiplying the sum of seven indicator congeners by a factor of five. If the sum of the six indicator congeners is multiplied by five, the resulting PCB_{total} in the shredder waste would be 35-45 mg/kg - close to the limit value. Jensen and Dalager (2015) summarise other shredder waste data showing similar levels. It is estimated that the quantities of shredder waste generated in Denmark varies between 100,000 and 150,000 t/year. If this waste contains 35-45 mg/kg PCBtotal, the total PCB content of the generated waste would be 3.5 - 6.8 t/year.

As described in section 2.3.8.10, a review of PCB-containing waste disposed of to MSW incinerators states that the destruction/removal efficiency of low-level PCB in waste was 90-99% of PCB content for waste with a PCB content of < 50 mg/kg (Jensen and Dalager, 2015). The study notes that addition of shredder waste will most likely increase the PCB concentration of the waste and increase the PCB concentration in the raw flue gas and bottom ash 2-5-fold. Most PCB in the waste will be destroyed if the combustion process is as optimal as possible as regards high temperature, long residence time, and appropriate oxygen pressure. It is further noted that regular and constant operation of the incineration plant is important, because start-up and close-down of operations diminish the destruction of PCB and increase new formation and emission of PCB (and dioxins) from the MSW incinerators considerably (Jensen and Dalager, 2015).

Possible sources of PCB in the shredder waste are small capacitors in fluorescent fixtures and other electrical equipment and PCB in paints. Hyks *et al.* (2015) show congener profiles for the PCBs in the shredder waste and discuss the possible sources of PCB in the shredder waste. They conclude that it is difficult to indicate the sources from the profiles. Small capacitors were produced with different chlorination levels and analysis of small capacitors in Denmark demonstrates that at least three types have been used, wherein the PCBs with higher chlorination levels have been used both for capacitors and several other applications. (Grontmij/COWI, 2013). For this reason, it is difficult to use "fingerprints" of PCB congener profiles in shredder waste to provide an indicator of the possible contribution from the capacitors.

The available data indicates that PCB-containing capacitors are to a large extent not removed from fluorescent fixtures and other equipment before shredding.

About 1.8 million tonnes waste are stockpiled in dedicated landfills for shredder waste. Analysis of shredder waste stockpiled in the three largest landfills shows that the average level in two of the landfills is around the limit value of 50 mg PCB_{total}/kg, while slightly lower in the third (Hyks *et al.*, 2015). If the average is assumed to be 50 mg PCB_{total}/kg, the total landfilled waste contains 90 tonnes of PCB. A life cycle assessment (LCA) of different treatment methods for the shredder waste landfilled in the period 2000-2009 concluded that scenarios including sorting of recyclables in connection with incineration of the sorting residues at an incineration plant resulted in environmental savings in all impact categories as well as regarding depletion of abiotic resources (Møller *et al.*, 2015), Currently, none of the incinerators incinerate landfilled shredder waste.

Hyks *et al.* (2015) note that no data are available for specific brominated flame retardants such as PBDE and HBCDD in landfilled shredder waste. In order to get an indication of the possible amount of brominated flame retardants in the waste, date on bromine content was assessed (brominated flame retardants typically have a bromine content of 50-83% with the highest percentage for decaBDE). The available analytical data demonstrated that the total content of bromine was increasing proportionally to the particle size fraction of the waste; i.e. the largest particle size fraction contained the largest amounts of bromine. According to the authors, this was likely linked to the fact that the larger particle size fractions contained more plastic, rubber and foam, which are all likely to contain brominated flame retardants. The average levels found in the >10 mg/kg fraction, which had the highest concentration, ranged from 683 - 1,270 mg/kg. The concentration in mixed samples ranged from 106 - 1,260 mg/kg. The maximum concentration limit of substances listed in Annex IV is for the sum of the four PBDE congeners (corresponding to commercial pentaBDE and octaBDE) is 10,000 mg/kg. Data on specific PBDEs in shredder waste from one plant demonstrated a concentration of the sum of all PBDEs well below 300 mg/kg. The limit value for HBCD is 1,000 mg/kg. No specific data on HBCD concentration in shredder waste in Denmark are available. In Norway, SFT (2008) found a concentration of 22 mg/kg in one sample and below the detection limit of 2 mg/kg in all other samples. Based on these findings, it is expected that the concentrations of HBCDD in shredder waste in Denmark are well below the limit of 1,000 mg/kg.

On the basis of the studies of hazardous substances in shredder waste, the Danish EPA recommends analysing the waste for a number of substances in its guidelines for classification of shredder waste as hazardous or non-hazardous waste. Of these, PCB is the only substance listed under the Stockholm Convention (Danish EPA, 2015b).

2.3.12.5 POP-contaminated sites

Danish soil quality criteria have been established for the following POPs covered by the Stockholm Convention (Danish EPA, 2018):

- DDT+DDE+DDD: 0.5 mg/kg
- Lindane: 0.5 mg/kg
- Pentachlorphenol: 0.15 mg/kg
- Perfluorinated alkyl acid compounds (incl. PFOS): 0.4 mg/kg.

There are no Danish soil quality standards for PCB, dioxins, or the brominated flame retardants covered by the Convention, and it is therefore up to the individual regions and municipalities to decide on the concentration levels that would trigger remediation measures.

Investigations of PCB in soil have been undertaken since the last NIP and it has been examined as to whether soil health-based quality criteria should be established. As described in section 2.3.8, based on an evaluation of health hazards by exposure to PCB, Larsen *et al.* (2014) concluded that a health-based soil quality criterion for PCBs is not considered to be relevant.

Investigations of PFOS and other perfluoroalkyl substances in soil are described in 2.3.9.

2.3.12.6 POPs in residues from waste incineration

The issues regarding POPs in residues from waste incineration is addressed in section 2.3.11.6.

2.3.12.7 POPs in residues from energy generation

The previous NIPs provided data on dioxins in fly ash from Danish power plants and in ash from small combustion plants fired by biomass. No data have been identified on newly added POPs in residues from energy generation, but residues from energy generation are not considered to be of concern.

2.3.12.8 Leachate from landfills

The previous NIPs provided data on dioxins and PFOS in leachate from landfills and the levels were found to be very low. No new data have been identified; therefore, POPs in leachate from landfills continue not to be considered to be an issue of concern.

2.3.12.9 POPs in sewage sludge

The Statutory Order on agricultural use of waste (BEK no. 1001 of 27/06/2018) sets out limit values or cut-off values for a number of heavy metals, as well as for a number of organic pollutants. With regard to POPs listed under the Convention, limit values have been established for PCB_7.

2.3.13 Future intentional production of POPs and need for exemptions

There are no plans for future intentional production of POPs in Denmark and there is no need for exemptions.

2.3.14 Programmes for monitoring releases, health risks and emission inventories

2.3.14.1 Monitoring of POPs in food and health risks

The content of dioxins and dioxin-like PCB, indicator PCB, and chlorinated pesticides in food is monitored continually as part of the Danish monitoring programme for food. Control of PCB and chlorinated pesticides is carried out as part of the control of animal products in accordance with EU Directive 96/23/EC, and as part of the control of other food products to provide an idea of the levels in selected food products which contribute significantly to human intake of chlorinated pesticides and PCB.

Control of dioxins and dioxin-like PCBs is also carried out to ensure that the limit values for dioxins and dioxin-like PCBs in food, set out in Regulation 1881/2006/EC (with later amendments), are not exceeded.

The monitoring programme for food is managed and executed by the Danish Veterinary and Food Administration. The results of this monitoring are reported periodically and available to the public on the Danish Veterinary and Food Administration website[20] or as quarterly and annual (the latest of these is for 2016) overview reports prepared in collaboration with the National Food Institute at DTU (DTU Food).

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On the website, there is also a contingency plan for handling of acute situations in relation to food contamination incidents[21].

2.3.14.2 Monitoring of POPs in animal feed

Each year the Danish Veterinary and Food Administration takes random samples of feed in order to check for contents of dioxin and PCB compounds. In 2011, a total of 65 samples were taken (latest report). Of these, 46 were taken as targeted random samples at animal feed companies, while the remainder was taken at farms in connection with investigations. The samples from the animal feed companies included a consignment of vegetable fats from the Netherlands, which exceeded the limit value considerably. This was the first time since the 2006 introduction of the EU limit values for dioxins and dioxin-like PCBs that concentrations were found to have been exceeded in animal feed. The results of the other samples were in line with previous years' results.

DDT, HCB and "drins" are analysed regularly in feed as part of the pesticide residue control programme. In the report covering the results from 2007-2014 (the latest report published), DDT was found in 17 out of 1399 samples (1.4%) while the other chlorinated pesticides occurred in less than 1% of the samples (DVFA, 2015c).

The Rapid Alert System for Food and Feed (RASFF) is used in situations where animal feed may constitute a serious and acute risk to consumers. The Danish Veterinary and Food Administration is the Danish national point of contact for RASFF. Thus, the Danish Veterinary and Food Administration receives warnings when prohibited or undesirable substances are discovered in feed, e.g. when a maximum value for an undesirable substance is exceeded. The Danish Veterinary and Food Administration assesses whether follow-up in Denmark is required. Similarly, Denmark is required to warn other Member States through RASFF of any observed risks associated with the feed.

2.3.14.3 Monitoring of POPs in the environment

Monitoring of POPs in the environment is part of the National Programme for Monitoring of the Aquatic Environment and Nature, NOVANA. Monitoring of nature and environmental conditions in Danish inlets and marine areas is carried out in a collaboration between the Danish EPA, the Danish Centre for Environment and Energy, Aarhus University (DCE) and the Geological Survey of Denmark and Greenland (GEUS).

The Danish EPA is overall responsible for the execution of the programme and for quality assurance of data. In practice, DCE, GEUS and some consulting companies including a reference analytical laboratory (presently Eurofins Miljø A/S), are the institutions implementing substantial parts of the surveillance programme. The results of the point source monitoring programme (mainly emission from WWTPs and industries to the aquatic environment) build extensively on reports from Danish municipalities, semi-public utility companies managing e.g. waterworks and WWTPs, and the Danish EPA.

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[20] https://www.foedevarestyrelsen.dk/Kontrol/Kontrolresultater/Sider/Organiske_miljo_og _procesforureninger.aspx

[21] https://www.foedevarestyrelsen.dk/SiteCollectionDocuments/Kemi%20og%20foedevarekvalitet/ Beredskabsplan%20kemi%202017.pdf

The NOVANA programme currently includes measurements of the following groups of POPs:

Marine environment:	PBDE including HBCDD in fish and bivalves Dioxins in fish, bivalves and sediment PCB in fish, bivalves and sediment PFOS (and other PFAS) in fish OC pesticides in fish
Lakes:	Dioxins in fish (control measurements from 2019) PCB in fish (control measurements from 2019) Heptachlor in fish (control measurements from 2019)
Water courses:	Dioxins in fish PCB in fish Heptachlor in fish (from 2019)
Point sources:	PFOS (and other PFAS)
Groundwater:	PCP PFOS (and other PFAS).

None of the POPs are included in the regular monitoring of freshwater, air quality, and atmospheric deposition, soil water, and drainage water; however, they may be included in specific studies or campaigns.

None of the POPs except PCP are included in the continuous groundwater monitoring carried out by GEUS, which is the specialist data centre for groundwater and borings. Since 2003, no measurements have been carried out of POP pesticides in groundwater. No POPs were found in measurements in 2003. A screening investigation of PFOS and other PFAS was included in the 2014 version of the programme (GEUS, 2015). PFOS was detected at two out of 40 sampling locations; the maximum concentration found was 0.10 µg/L.

The results of the monitoring are reported annually and are made available to the public at the Danish Centre for Environment and Energy website (www.dmu.au.dk).

2.3.14.4 Emissions of POPs from enterprises

In 2006, the European Parliament and the Council adopted a regulation (Regulation no. 166/2006) concerning the establishment of a European Pollutant Release and Transfer Register (the PRTR Regulation). The register, termed E-PRTR (European Pollutant Release and Transfer Register), contains data on emissions from more than 30,000 enterprises in Europe.

The PRTR Regulation encompasses 91 substances, including the following substances which are also covered by the Stockholm Convention (when emissions exceed the defined emission thresholds): aldrin, chlordane, chlordecone, DDT, dieldrin, diuron, endosulfan, endrin, 1,2,3,4,5,6-hexachlorocyclohexane (HCH), lindane, mirex, dioxins, pentachlorobenzene, HCBE, PCB, toxaphene, PBDEs (total of penta-, octa- and decaBDE), PCP, SCCPs, and hexaBB.

The above information is available on the E-PRTR website:
(http://prtr.eea.europa.eu/#/pollutantreleases)

The register contains few data on Danish sources of POPs, probably because emissions from Danish point sources are generally below the threshold values.

2.3.14.5 Atmospheric emissions

The Danish Centre for Environment and Energy (DCE), Aarhus University, is responsible for preparing the official annual inventories of Danish emissions to the atmosphere. The Danish Centre for Environment and Energy reports the total estimated emissions of dioxins, PCBs and HCB to the EU and the UNECE under the Convention on Long-Range Transboundary Air Pollution (CLRTAP) from 1979.

These inventories are available to the public at the European Environment Agency website (www.eea.europa.eu) and the Danish data are furthermore published in technical reports from the DCE. The data on POPs are summarised in section 2.3.11.

2.3.15 Information for the public and information exchange with other parties to the Convention

2.3.15.1 Information for the public

Communication about issues relating to POPs takes place at many levels and in many fora. The public is provided information about POPs primarily as part of more general information on health and hazardous substances, which, in addition to POPs, include endocrine disruptors in general, heavy metals, sensitizing substances, and solvents.

The following includes a few examples of communication about POPs, specifically.

The PCB guide. An inter-ministerial PCB guide and a helpdesk have been established (www.pcbguiden.dk) as one of the initiatives under the Action Plan on Managing PCB in Buildings. This guide is targeted at four groups of stakeholders: the general public, construction companies, building owners and municipalities. The guide provides information to the general public about the health risks associated with PCB and what you can do if you suspect PCB in your home or at your workplace, among other issues. The guide contains step-by-step instructions for construction companies and building owners on how to identify PCB and manage building materials and waste containing PCB.

The guide was established jointly by the Agency for Palaces and Cultural Properties, the Ministry of Social Affairs and Integration (the responsibility has since been moved to the Ministry of Housing, Urban and Rural Affairs), the Danish Business Authority, the Danish EPA, the Danish Health and Medicines Authority (now the responsibilities are at the Danish Health Authority and the Danish Patient Safety Authority), and the Danish Working Environment Authority.

Environment and health. The Advisory Scientific Committee on Environmental Health of the Danish Health Authority publishes the public information magazine “*Miljø og Sundhed*” (Eng: Environment and Health). The magazine is published three times a year. Nearly every issue of the magazine contains articles related to POPs. The most recent issue with a summary on new contaminants in the Arctic (Vorkamp *et al.*, 2018).

Dioxins and dioxin-like PCBs in food. The Danish Veterinary and Food Administration (DVFA) website "*Kend kemien"* [Eng: “Know the chemistry"] provides information about dioxins and dioxin-like PCBs in food, about harmful effects and what types of food are especially likely to contain the substances. The webpage "Gravid med mindre uønsket kemi” [Eng: Pregnant with less undesired chemistry] includes specific recommendations for pregnant women.

The DVFA's campaign "*Mad med mindre kemi* " [Eng: Food with less chemistry] provides information on how to avoid undesired chemistry in food e.g. to avoid fluorinated substances in packaging.

DAKOFA. As part of the work to clarify issues about PCB in building materials and building waste, a number of initiatives have been carried out under DAKOFA, the Danish Competence Centre on Waste, in the form of conferences and meetings. Furthermore, meetings concerning the incineration and other treatment of shredder waste and classification of hazardous substances have been undertaken.

Videnskab.dk. The website *Videnskab.dk,* funded by a number of government agencies and research councils, contains a large number of articles on POP-related topics.

Information about POPs in the environment, food, and animal feed is disseminated via the Internet by the relevant agencies and institutions.

2.3.15.2 Information exchange with other parties to the Convention

Through reports to the UNECE, Denmark annually exchanges information on emissions of certain POPs with those parties to the Convention which are also parties to the POP Protocol.

Under the Nordic Environmental Action Plan 2013-2018, Nordic working groups have been set up for the various substance areas. The working groups exchange information and instigate studies. A number of the priorities of the action plan address investigations in and preventing and reducing transboundary transport of POPs.

Through its membership in the EU, Denmark regularly exchanges information regarding POPs with other Member States.

Danish research institutions cooperate with research institutions in other Member States as well as other parties on a number of EU-funded research projects concerning POPs.

As a participant in the Rapid Alert system, Denmark also exchanges information with the other EU countries about POPs in food and animal feed.

2.3.16 Activities by NGOs

A number of Danish NGOs are active in the field of hazardous chemical substances of concern in relation to the environment or human health. None of these NGOs specifically focus on POP substances, but they include POPs and other hazardous substances when relevant in relation to wider issues they address, such as air pollution from domestic stoves, municipal waste incineration, legacy pesticides, chemicals in building and construction, use of sewage sludge on agricultural land etc.

Danish NGOs undertaking such activities include:

- The Danish Society for Nature Conservation (DN) (www.dn.dk)
- The Ecological Council (www.ecocouncil.dk)
- The Consumers' Council, TÆNK (www.taenk.dk)
- Greenpeace Denmark (www.greenpeace.org/denmark/da/)
- The National Association for Information on Pollution from Wood Stoves (www.braenderoeg.dk)
- Certain industrial branch organisations, e.g. those within the building and construction sector (e.g. www.bfa-ba.dk, which is a building sector organisation sub-group dealing with working environment issues within the sector).

2.3.17 Technical infrastructure for POP assessment, measurements, analyses, and research and development

2.3.17.1 Research into the presence and effects of POPs

POPs are included in a number of research programmes at a large number of Danish research institutions.

Much of this research concerns POPs in the Arctic and is part of the work under the Arctic Monitoring and Assessment Programme, AMAP. The Danish EPA is responsible for Danish participation in AMAP in consultation with an inter-ministerial coordination group which includes representatives from the Government of Greenland and the Home Government of the Faroe Islands. Denmark's participation in the environmental work of the Arctic Council is funded via the environmental support scheme for the Arctic (Da: *Miljøstøtteordningen for Arktis*).

The following institutions are working on issues related to the presence and effects of POPs:

- The Danish Centre for Environment and Energy at Aarhus University has several departments which have research projects linked to impacts from POPs on the environment, and the Arctic environment in particular.
- The Institute of Public Health at the University of Southern Denmark carries out research into e.g. harmful effects of perfluorinated substances and other POPs, focusing in particular on development and reproduction. This research includes the effects of exposure to PFOS, PCB, pentachlorohexane and HCB. For many years now, the Institute has been carrying out epidemiological studies of the effect of POPs in the Faroe Islands.
- The Arctic Health and Molecular Epidemiology section at the Department of Public Health at Aarhus University is associated with the AMAP Human Health Assessment Group (HHAG). The research activities include: monitoring and assessing the effects of heavy metals and organochlorine compounds on human health in Greenland, and assessment exposure to POPs and adverse health effects e.g. immune, neurological and reproductive systems, and cancer.
- The Section of Environmental Health at the Department of Public Health at the University of Copenhagen researches the use of PCBs and dioxin-like activity as biomarkers of exposure in blood samples from children and women.
- The Department for Occupational and Environmental Medicine at Bispebjerg Hospital is working on a range of research projects to examine the effect of POPs and other environmental toxins, e.g. reproductive health, following residential high-level exposure to semi-volatile PCB in indoor air.
- The National Food Institute (DTU Food) at the Technical University of Denmark has examined the presence of perfluorinated substances in food contact materials and options for risk management.
- The Department of Energy, Environment and Indoor Climate, Danish Building Research Institute, Aalborg University is working on studies concerning remediation of PCB-related problems in indoor climate. The institute also hosts the PCB network with frequent seminars on issues related to PCB in buildings.
- National Research Centre for the Working Environment examines issues related to PCB in the working environment.

Examples of other research units which have published results in recent years concerning POPs include the Department of Clinical Medicine Aarhus University, Centre for Foetal Programming, Statens Seruminstitut and Department of Growth and Reproduction, Rigshospitalet.

2.3.17.2 Laboratories with capacity to measure POPs
The technical infrastructure for POPs measurements has been described in previous NIPs.

2.3.18 Particularly exposed population groups

2.3.18.1 Workers involved in management of POPs containing materials
Building sector. Workers involved in building renovation and demolition may be exposed to high levels of PCBs and SCCPs. The Danish Working Environment Authorities have developed rules regarding safety when working with building components containing PCB. Detailed guidelines for working with PCB-containing materials have further been developed by the Working Group for the Working Environment in Building and Construction [Branchefællesskabet for arbejdsmiljø i Bygge & Anlæg (BBA)] and the Demolition and Environmental Remediation section [Nedrivning og Miljøsanering] under the Danish Construction Association. The Danish Working Environment Authorities have not developed rules for safety when working with SCCPs, but mention on their website that the same rules that apply to PCB also apply to works involving SCCPs.

The Danish Working Environment Authorities do not mention HBCDD on their website. Working with flame retarded EPS or XPS is usually not considered to require use of specific personal protective equipment. The EU Risk Assessment for HBCDD mentioned that not enough data for estimation of the exposure from industrial end-uses of semi- and end-products containing HBCDD are available (EC, 2008a). The exposure depends on how the material is handled (e.g. dust generating cutting, heating e.g. with a hot wire for cutting boards), the circumstances in the work environment (ventilation, the shaping of the workplace) and the frequency and duration of the work task. The risk assessment further noted "*Other end-uses, such as handling of polystyrene-boards are assumed to result in very low exposure levels, and, therefore, there is no scenario for this use"* (EC, 2008a).

Recycling of electronics. A number of studies from the last twenty years demonstrate that workers in recycling facilities for waste electrical and electronic equipment (WEEE) may be exposed to brominated flame retardants above the level of the general population (Lassen *et al.*, 2014b). No data on exposure of workers in recycling facilities in Denmark are available, but elevated exposure to PBDE of workers in WEEE recycling facilities has been demonstrated in China, Sweden, Norway and the USA (as reviewed by Lassen *et al.*, 2014b). A Swedish study showed the median total PBDE blood level in WEEE recycling facility workers was seven times higher than the reference group, which consisted of hospital workers and computer clerks (Sjodin *et al.,* 1999 cited by Schecter *et al.*, 2009). A later study showed that dust-reducing industrial hygiene improvements clearly reduced the occupational exposure to higher brominated diphenyl ethers. In 2000, the decaBDE concentrations did not differ from levels observed in a reference population, whereas the levels of hexa- to nonaBDEs (in commercial octaBDE) still were elevated (Thuresson *et al.*, 2006a). Schecter *et al.* (2009) showed an approximate 6-fold to 33-fold increase in electronic recycling facility workers' PBDE exposure as compared with the US general population. Rosenberg *et al. (*2011) measured PBDEs, and other halogenated flame retardants at four EEE recycling facilities in Finland and conclude that the concentrations reported may pose a health hazard to the workers. Today, dismantling of WEEE in Denmark is limited as most WEEE is exported for dismantling abroad.

The EU risk assessment assesses possible occupational exposure to decaBDE in offices with large amounts of electronic equipment and reaches the conclusion that the inhalation and dermal exposure to decaBDE is negligible (EC, 2002).

Workers in waste collection centres. Workers on waste collection centres may be exposed to POPs in waste delivered to the stations if the waste is not properly packaged and labelled. Of particular concern is PCB and SCCP in double glazed windows, as such windows may not be adequately identified by the person who disposes of the windows and the windows are further handled by the personnel. No data are available on actual exposure level in Denmark.

Exposure to dioxins and other unintentionally formed POPs. Occupational exposure to dioxins and other unintentionally formed POPs may take place in different occupations. No data on occupational exposure to these substances in Denmark have been identified.

Sweetman *et al.* (2004) evaluated occupational exposure to dioxins in the UK. The study concluded that significant occupational exposure to dioxins could take place in secondary aluminium and steel production, processes also known for significant environmental releases of dioxins. In Denmark, no facilities for secondary production of metals are in operation.

A German study of exposure of chimney sweeps to dioxins concluded that internal exposure to dioxins in chimney sweeps were significantly higher than in the control group (Wrbitzky *et al.*, 2001). However, differences were small and within the range of the internal exposure to dioxins in blood found in the general population in Germany.

A study of occupational dioxin exposure of workers in municipal waste incinerators in Flanders (Belgium) showed no increased dioxin-like serum levels in maintenance workers in the two municipal waste incinerators (Meester *et al.*, 2018). The authors conclude that there is no additional risk for dioxin exposure in the two waste incinerators (Meester *et al.*, 2018).

Workers may be exposed to dioxins and other unintentionally produced POPs formed from some of the sources described in section 2.3.11. This may include exposure to dioxins from wood stoves in residential areas or close to waste incinerators, and exposure to diesel engine exhaust in various occupations (professional drivers, auto mechanics, and workers involved in road maintenance). The significance of the occupational exposure has not been investigated; these exposure situations have not been included in assessments of occupational exposure to dioxins where high-exposure situations have typically been production and application of PCP and other chemicals with relatively high contents of dioxins.

2.3.18.2 Greenland and the Faroe Islands

The populations of Greenland and the Faroe Islands are particularly exposed to POPs through their significant intake of fish and marine mammals. However, since Greenland and the Faroe Islands are not covered by this implementation plan, a description of this issue has not been included.

2.3.18.3 Women of childbearing age and women who are breastfeeding

Pollution with dioxins and other POPs still poses a particular risk for girls and women of childbearing age, as well as pregnant and breastfeeding women because the POPs may be transferred to the foetus. On the website "*Gravid med mindre uønsket kemi*" [Pregnant with less undesired chemistry], the Danish Veterinary and Food Administration recommends that this group of women reduce or avoid the intake of certain fish and avoid packaging with fluorinated substances among other suggestions.

2.3.18.4 Socio-economic impacts

No new information is available since the latest NIP.

2.3.19 Systems for assessment and inclusion of new substances under the Convention

Within the EU, Denmark is collaborating with the other Member States on assessing new candidate POPs, on regulating these substances within the EU, and on nominating substances under the POP Protocol and the Stockholm Convention.

Through a range of study programmes, Denmark contributes to demonstrating the presence of persistent organic pollutants in the marine environment and in the Arctic environment. In recent years, studies also have been carried out covering fluorinated substances that are under consideration for possible inclusion in the Stockholm Convention: The substances in question are perfluorooctanoic acid (PFOA) and perfluorohexane sulfonic acid (PFHxS).

Furthermore, studies are being carried out on the presence of a number of persistent brominated flame retardants (apart from those listed under the convention), PFAS and siloxanes (summarised by Vorkamp and Rigét, 2013).

3. Strategy and action plan elements

3.1 Policy statement

Efforts to combat harmful chemicals have been rendered high priority in Denmark for many years. As stated in Denmark's national strategy for sustainable development "*Vækst med omtanke*" ("*Considered growth"*), the goal is that in 2020 no products or goods should contain chemicals that lead to a significant negative impact on health or the environment.

In order to meet the goal in the Stockholm Convention to protect people and the environment from POPs, it is important to work towards having substances which meet the POPs criteria regularly added to the Convention and regulated under it. An important signal is that substances are now regulated and banned which are still in use, so that focus is not just on problems stemming from the past. The first substances to be regulated under the Convention had very limited use globally. Since the last implementation plan from 2013, six new POPs have been listed under the Convention, several of which were being used extensively globally, and Denmark supported inclusion of these substances.

The updated national implementation plan reports that Denmark lives up to the obligations under the Convention and therefore the plan only contains very few new initiatives. These aim in particular at destruction of the POPs present in the waste streams.

Denmark will continue to work actively to raise the level of protection and minimise the environmental and health impacts of POPs, nationally as well as in international fora.

3.2 Implementation strategy

Denmark has been intensifying its efforts within the chemicals area since the 1980s. The objective is to reduce risks to human health and the environment from the use of chemicals. This is being done e.g. through strong international collaboration (including Nordic collaboration), regulation, control and sanctions, and through providing the public and enterprises with more knowledge about chemicals.

POPs currently form an integral part of existing systems and strategies for regulation, approval, monitoring and waste management in relation to chemicals. In the context of the implementation of the Stockholm Convention, it has therefore not been necessary to strengthen the institutional or regulative framework for managing and monitoring POPs in Denmark. However, the requirements of the Convention have helped highlight POPs and have been a driving force for new activities.

Implementation of the Stockholm Convention's requirements for POPs and for waste containing POPs are moreover characterised by a close interplay between EU regulation and measures, on the one hand, and national regulation and measures on the other. To a great extent, Denmark implements the requirements of the Stockholm Convention through existing legislation, strategies and programmes.

The Danish Implementation Plan has been prepared by the Ministry of Environment and Food of Denmark. The Department will be reviewing and updating the plan regularly as required.

3.3 Activities, strategies and action plans by substance group

3.3.1 Measures to reduce or eliminate the release of decaBDE, other PBDEs and hexaBB

3.3.1.1 Implementation legislation

The requirements of the Convention have been implemented in the EU's POP Regulation, which is described in more detail in section 2.2.5.2 concerning the use of decaBDE, in section 2.2.5.2 as regards the other brominated flame retardants, and in section 2.2.5.7 concerning waste.

According to the Danish Statutory Order on WEEE, plastics containing brominated flame retardants must be selectively collected from waste electrical and electronic equipment and delivered to enterprises approved to manage waste containing bromine.

3.3.1.2 Status

The most important problems concerning brominated flame retardants are linked to the presence of decaBDE in waste and are further described in section 2.3.2.4, whereas issues with regard to incineration of all PBDEs (incl. decaBDE) and hexaBB are described in section 2.3.10.1.

Incineration of the substances. One of the actions put forth in the last NIP was to encourage the European Commission to prepare a study to validate whether technical pentaBDE is sufficiently destroyed in MSW incinerators. As described in section 2.3.10.1, in an email to the Danish EPA of 21 June 2013, the European Commission stated that according to the experts the European Commission had consulted, it appeared that PBDEs could be incinerated in MSW incinerators if measures were taken to ensure that bromine concentrations were not excessive. In a desktop study on destruction of persistent organic compounds in combustion systems carried out by Umeå University for the Swedish Environmental Protection Agency, Lundin and Jansson (2017) concluded that PBDE is destroyed in MSW incinerators operated at temperatures of ≥850ºC but noted that the confidence level is low because of the limited number of studies available.

The actual destruction efficiency for decaBDE and other PBDEs in Danish incineration plants is currently under evaluation in an assessment for the Danish EPA.

DecaBDE. As described in section 2.3.2, it has been concluded by EFSA that current dietary exposures to decaBDE in the EU are unlikely to raise health concerns. Furthermore, it has been concluded to be unlikely that current levels found in Danish sludge would pose significant risks to the soil environment and that environmental levels in Denmark are not generally of concern.

As described in section 2.3.2.4, decaBDE may mainly be present in the waste stream for WEEE, waste building materials, and shredder waste. DecaBDE was used in electrical and electronic equipment until 2008 and for other applications until recently, so the substance may be yet present in the waste stream for many years into the future. The plastic waste is assumed to be disposed of primarily to municipal waste incinerators, but with increased focus on recycling of plastics, there is a risk that the substance may be reintroduced into society with recycled plastics.

The presence of decaBDE in the plastics associated with WEEE, building materials and vehicles prevents recycling of thermoplastics with any brominated flame retardant, as the substance has been widely used in many types of thermoplastics, and the screening methods commonly used can only distinguish between plastics with or without bromine, but not determine the specific brominated substances. Because of the widespread application of the flame retardant, it is not considered likely that dissemination of further information on the specific applications of the substance could facilitate further recycling of flame retarded plastics from these applications. Further recycling of plastics containing brominated flame retardants (if desired) needs to wait until decaBDE and other listed brominated flame retardants are out of the waste stream. The MFVM will follow the situation and prepare advises to the recycling companies in cooperation with the Danish Plastics Federation.

Technical pentaBDE. On the basis of the answer from the European Commission, it was decided by the Danish EPA not to take any further action on requirements to separate fractions of household waste containing pentaBDE for disposal as hazardous waste, as it was believed that pentaBDE was sufficiently destroyed in municipal waste incinerators. The use of pentaBDE decreased markedly in the EU around 2000 and ceased altogether in 2004. As mentioned in the previous NIP, a study carried out for the European Commission (ESWI, 2011) assessed that essentially all of the technical pentaBDE in vehicles in the EU would be disposed of by 2016. With this in view, no more initiatives are seen as being needed to fulfil the requirements of the Stockholm Convention and the POP protocol.
Technical octaBDE. Technical octaBDE was used in the EU until 2005. As mentioned in the previous NIP, at EU level in 2010 it was estimated that around 128 tonnes octaBDE in WEEE was disposed of, and a report for the European Commission (ESWI, 2011) estimated that all octaBDE would effectively have been disposed of by 2012. It is assumed that technical octaBDE is currently in large part out of the waste stream in Denmark and that no more initiatives are needed to fulfil the requirements of the Stockholm Convention and the POPs Protocol.

HexaBB. Considering that hexaBB has not been used since the 1970s, the previous NIP found it likely that an insignificant number of articles containing hexaBB remained in circulation. No more initiatives are believed to be needed to fulfil the requirements of the Stockholm Convention and the POP protocol.

3.3.1.3 New initiatives

The following table indicates the new initiatives that will be taken in relation to the management of decaBDE, other PBDEs and hexaBB.

TABLE 22. New initiatives in relation to decaBDE and other PBDEs

No	Initiative	Description	Responsible institution	Timeframe
1	Control and awareness raising	Undertake control of products on the Danish market: Assess how materials with PBDEs can be separated from the waste stream prior to recovery and other waste treatment Prepare advice for recycling companies	MFVM	Continually

3.3.2 Measures to reduce or eliminate the release of SCCPs

3.3.2.1 Implementation legislation

The requirements of the Convention have been implemented in the EU's POP Regulation, which is described in more detail in section 2.2.5.2 concerning the use of the SCCPs, and in section 2.2.5.7 concerning waste. The EU POP Regulation is supplemented by the Danish Statutory Order 854 of 05/09/2009 on PCP.

3.3.2.2 Current issues

SCCPs is not intentionally placed on the market in Denmark in concentrations above the limit value of 1% stated in the Stockholm Convention and the POP Protocol.

The major issue for this substance concerns SCCPs in building materials. Materials containing SCCPs in concentrations above 1% are cf. §3,2 of the Statutory Order on Waste (as amended by Statutory Order 715 of 13 May 2015) classified as hazardous waste when they are disposed of due to their classification as carcinogenic. Consequently, in order to identify materials with SCCPs, screening for SCCPs should be carried out as part of renovation and demolition activities. It is common to undertake screening for SCCPs along with screenings for PCB and heavy metals. Even though it is required, screening for SCCPs is not specifically mentioned in the Statutory Order on waste. The practice may vary across the country and a survey undertaken in August 2018 demonstrates that the regulations may not be sufficiently enforced in some municipalities (Ingeniøren, 2018). It is common to include SCCPs when building materials are screened for PCB, but the period where SCCPs were used exceeds the PCB period and SCCPs were to some extent used as substitutes for PCB.

The actual destruction efficiency for SCCPs in Danish MSW incinerators is currently under evaluation in an assessment for the Danish EPA.

The MFVM will evaluate the need for further information for contractors, property owners, municipalities, and other stakeholders involved in activities related to building renovation and demolition on identification and handling SCCPs waste. If the evaluation demonstrates the need for further information, the MFVM will prepare further guidelines.

3.3.2.3 New initiatives

The following table indicates the new initiatives that will be taken in relation to the management of SCCPs.

TABLE 23. New initiatives in relation to SCCPs

No	Initiative	Description	Responsible institution	Timeframe
1	Evaluate need for further information on SCCPs	Evaluate the need for further information on SCCP-waste to contractors, property owners, municipalities, and other stakeholders involved in activities related to building renovation and demolition. If the evaluation demonstrates the need for further information, the MFVM will prepare it accordingly.	MFVM	2019-2020

3.3.3 Measures to reduce or eliminate the release of HBCDD

3.3.3.1 Implementation legislation

The requirements of the Convention have been implemented in the EU's POP Regulation, described in more detail in section 2.2.5.2 concerning the use of HBCDD, and in section 2.2.5.7 concerning waste.

3.3.3.2 Status

The most important issues concerning HBCDD are linked to the presence of substances in waste. HBCDD can be present in waste from electrical and electronic equipment (WEEE), shredder waste and building waste. In WEEE and shredder waste the issues are similar to those discussed for decaBDE in the previous section.

As described in section 2.3.6, HBCDD has been widely used in XPS sheets, where the majority of the sheets have been flame retarded even when flame retarded grades were not required. With regard to EPS sheets, HBCDD was not often added, but it may occasionally be present in sheets imported from countries where such sheets have been flame retarded e.g. Germany or Poland.

The limit value for HCBDD in waste established in the POP Regulation is 1,000 mg/kg, meaning that EPS/XPS sheet waste containing HCBDD is classified as hazardous waste and must be disposed of accordingly. It is not common knowledge among contractors, property owners, municipalities, and other stakeholders as to how sheets with HCBDD are identified; all EPS/XPS is currently disposed of along with other combustible building waste to MSW incinerators.

The presence of HBCDD in EPS/XPS prevents the recycling of these materials from the construction sector. It is therefore essential that waste from renovation and demolition is separated from waste from current uses, if improved recycling schemes are to be established.

The destruction efficiency for HBCDD in Danish MSW incinerators is currently under evaluation for the Danish EPA. Based on the results of the assessment, the MFVM will assess whether selective collection and disposal of EPS/XPS with HBCDD should be required.

On this basis, the MFVM will evaluate the need for further information for contractors, property owners, municipalities, and other stakeholders involved in activities related to building renovation and demolition on identification and handling of HBCDD-waste. If the evaluation demonstrates the need for further information, the MFVM will prepare the required guidelines.

3.3.3.3 New initiatives

The following table indicates the new initiatives that will be taken in relation to the management of HBCDD.

TABLE 24. New initiatives in relation to HBCDD

No	Initiative	Description	Responsible institution	Timeframe
1	Assess the need for selective collection and disposal of EPS and XPS with HBCDD	Assess whether selective sorting with the aim of destruction of EPS and XPS with HBCDD should be required on the basis of an evaluation of the efficiency of incineration of HBCDD in MSW incinerators.	MFVM	2019-2020
2	Evaluate need for further information on HBCDD	Evaluate the need for further information for contractors, property owners, municipalities, and other stakeholders involved in activities related to building renovation and demolition on identification and handling of HBCDD-waste. If the evaluation demonstrates the need for further information, the MFVM will prepare the required guidelines.	MFVM	2019-2020

3.3.4 Measures to reduce or eliminate the release of PCP, PCNs and HCBD from intentional use

3.3.4.1 Implementation legislation

The requirements of the Convention have been implemented in the EU's POP Regulation, which is described in more detail in section 2.2.5.2 concerning the use of the three substances, and in section 2.2.5.7 concerning waste.

3.3.4.2 Current Issues

Based on the information presented in the baseline, it is believed that there are no current intentional uses of the three substances and no significant issues with regard to the presence of the substances in the waste streams. No further actions are needed in order to comply with the requirements of the Stockholm Convention and the POP Regulation.

3.3.5 Measures to reduce or eliminate the release of PCB from intentional uses

3.3.5.1 Implementation legislation

The commitments under the Stockholm Convention relating to PCB have been implemented in Article 3(1) of the EU's POP Regulation and in the Danish Statutory Order on PCB/PCT, which implements the PCB/PCT EU Directive and to which the POP Regulation refers. Danish regulation on PCB contains requirements that are more stringent than what follows from the Stockholm Convention and the PCB/PCT Directive, as referred to in section 2.2.5.4. The Convention's requirements for waste management have been implemented in the POP Regulation and are supplemented by a number of EU Directives on management, including landfilling/depositing waste. These Directives and the Danish provisions implementing them in Denmark are described in section 2.2.5.7.

3.3.5.2 Current issues

The previous NIP comprised a number of new actions on PCB including 19 initiatives in the Danish Government's “Action Plan on Managing PCB in Buildings".

PCB in buildings. The 19 initiatives of the Action Plan on Managing PCB in Buildings have all been implemented. The requirements for surveys of PCB in building materials are established in the statutory order on waste. Guidelines for identification and management of PCB-containing waste have been developed and recommended action levels for PCB in indoor air have been established. As a consequence of the implementation of the requirements, the quantities of PCB-containing building waste have increased 100-fold as compared to the level ten years ago. A survey undertaken in August 2018 demonstrates that the regulations may not be sufficiently enforced in some municipalities (Ingeniøren, 2018). However, the requirements are clearly stated in the statutory order and the proper implementation of the requirement is described in guidelines. With the actions taken, Denmark is effectively implementing the requirements of the Stockholm Convention and the EU legislation and no further initiatives are considered necessary.

Health risk of PCB in indoor air. Recommended actions levels for PCB in indoor air have been established by the Danish Health Authority. As described in section 2.3.8.14, current knowledge on long-term health effects of exposure to PCBs does not allow for appropriate risk assessment of indoor air exposure because PCBs released from indoor sources have high contents of lower chlorinated and semi-volatile PCBs that are mostly non-dioxin-like. As current risk paradigms on PCB rely entirely on dietary sources and dioxin-like PCB congeners, there is a gap in knowledge on long-term health effects following airborne PCB exposure in homes and schools. The ongoing research programme, HESPERUS, aims to unravel whether exposure to indoor PCB released from building materials is associated with reproductive health risk. When the results of the programme are ready, the Danish Health Authority will assess whether further actions would be justified.

PCB in soil. Based on an evaluation of health hazards related to exposure to PCB, Larsen *et al.* (2014) concluded that a health-based soil quality criterion for PCBs was not considered relevant (see section 2.3.8.12). Based on this evaluation, no criteria in relation to soil and groundwater quality regarding PCB have been established. No further actions on PCB in soil will be initiated.

PCB in electrical equipment. Data from the Danish EPA's Waste Database System demonstrate that large amounts of PCB-containing transformers and capacitors are still disposed of. A survey is ongoing to assess the data and the management of PCB-containing equipment and waste in electrical equipment. Preliminary results indicate that the PCB concentration generally is below 50 ppm PCB, that large PCB-transformers (> 500 ppm PCB) have been disposed of in Denmark, and that a smaller number of large PCB capacitors may still be present in society in Denmark. On the basis of the results, the MFVM will evaluate the need for further initiatives regarding PCB in electrical equipment and oil.

PCB in shedder waste and incineration of PCB-containing waste in municipal waste incinerators. An issue brought forward as part of the stakeholder consultation of this implementation plan is the increasing rate of incineration of shredder waste in municipal waste incinerators and incineration of building waste with PCB < 50 mg/kg in the same incinerators. The incineration of shredder waste with energy recovery may concerns both the 100,000 - 150,000 tonnes of new shredder waste generated each year and the 1.8 million tonnes waste currently disposed of in landfills with sections dedicated to shredder waste. At the moment there are no specific plans to incinerate the 1.8 million tonnes waste landfilled. One of the actions of the previous NIP was an examination of the possibilities for identifying PCBs in shredder waste and the possible management of this waste. As described in section 2.3.8.10, a review of PCB-containing waste disposed of to conventional (municipal) waste incinerators states that the destruction/removal efficiency of low-level PCB in waste was 90-99 % of the PCB content (Jensen and Dalager, 2015). The study concluded that it had not been possible to make an adequate assessment of literature data that could theoretically be directly applicable to the conditions at the individual Danish incinerator plants (Jensen and Dalager, 2015). The study suggested that a more thorough investigation would be appropriate. Considering the large quantities of PCB to potentially be disposed of in municipal waste incinerators and the controversy regarding destruction efficiency, assessment of destruction efficiency will be revisited along with efficiencies for other POPs when the ongoing study of the fate of other POPs by incinerations is finalised. On this basis, it will be assessed to what extent further investigations or other initiatives would be needed.

3.3.5.3 New initiatives

The following table indicates the new initiatives that will be taken in relation to the management of PCB throughout the lifecycle of the substance.

TABLE 25. New initiatives in relation to PCB

No	Initiative	Description	Responsible institution	Timeframe
1	PCB in transformers and capacitors	Finalise current study on PCB in transformers and capacitors and evaluate if further initiatives are needed	MFVM	2019-2020
2	Follow the results of the risk assessment of low-chlorinated PCBs	Follow the results of the ongoing HESPERUS project, which assesses the risk of low-chlorinated PCB in the indoor environment. Assess to what extent further actions would be needed based on the results of the project.	The Danish Health Authority	2019-2022
3	Further assessment of the destruction of PCB in MSW incinerators	Revisit the assessment of destruction efficiency for PCB along with results of the ongoing assessment of efficiencies for other POPs. Assess, on this basis, the need for further initiatives.	MFVM	2019-2020

3.3.6 Measures to reduce or eliminate the release of PFOS

3.3.6.1 Implementation legislation

The requirements of the Convention have been implemented in the EU's POP Regulation, which is described in more detail in section 2.2.5.4 concerning the use of PFOS, and in section 2.2.5.7 concerning waste.

3.3.6.2 Current Issues

Current use of PFOS. The POP regulation includes exemptions for use of PFOS in (b) photoresists or anti-reflective coatings for photolithography processes, (c) photographic coatings applied to films, papers, or printing plates, (d) mist suppressants for non-decorative hard chromium (VI) plating in closed-loop systems, and (e) hydraulic fluids for aviation (exemption (a) regarding use as wetting agent in controlled electroplating systems expired on 26 August 2015).

PFOS was used as mist suppressant for non-decorative hard chrome plating in Denmark until recently. The substance has been replaced in all applications, and Denmark is planning to withdraw the notification for this acceptable use. Information on the used alternatives and Denmark's experience with the substitution will be communicated to the European Commission.

No use in Denmark for other exempted applications have been identified.

PFOS in waste. As mentioned in section 2.3.9.3, carpets are expected to comprise the main source of PFOS in waste but PFOS may also be present in some leather upholstery in furniture and car interiors, as well as in other textiles, cardboard and paper. As PFOS has not been used for these applications since 2002, PFOS-containing products still in use would be more than 26 years old. It cannot be excluded that some carpets are still in use, but overall it is considered that the quantities of PFOS in the waste stream would be limited. In Denmark, carpets, textiles, upholstered furniture, and other articles that may be surface-treated with PFOS, are currently mainly disposed of via MSW incineration with energy recovery.

One of the listed actions of the previous NIP was an assessment of the presence of PFOS in household waste. PFOS was included in the LOUS survey of PFOS, PFOA and other PFAS as mentioned in section 2.3.9. There is no selective waste collection of articles containing PFOS taken into use prior to the ban. Considering the small amounts of PFOS currently in waste, and the fact the PFOS-containing articles cannot easily be distinguished from other articles, it is assessed that setting up selective waste collection of articles containing PFOS would be disproportionate.

PFOS in waste incineration. As discussed in section 2.3.9.4, one of the actions of the previous NIP was to encourage the European Commission to carry out a survey to validate whether PFOS can be adequately destroyed in ordinary waste incineration processes. It is still uncertain as to what extent PFOS is destroyed in MSW incinerators operating at a temperature of 850˚C.

When an ongoing desk study for the Danish EPA on destruction of PFOS and other POPs in MSW incinerators operating at a temperature of 850˚C is finalised, the MFVM will evaluate the need for further initiatives.

Soil and groundwater contamination. One of the actions of the previous NIP was to investigate possible soil and groundwater contamination with PFOS. A literature review of soil and groundwater contamination by PFOS and other PFAS and two screening investigations of groundwater at a number of potentially contaminated sites in Denmark were undertaken as described in section 2.3.9.6. Contamination with PFOS was found at several fire-fighting training grounds and the literature review indicated other potentially contaminated sites. Remediation has been undertaken for at least one site. In 2014, the Danish Nature Agency instructed the municipalities that the regular control of drinking water supplies should also include PFAS if one or more facilities that may have used PFAS are or were in operation. In order to assist the regions and municipalities, the Danish regions' knowledge centre for environment has published a detailed manual on investigation and remediation of sites contaminated with PFAS (DRER, 2018). The basis for further investigation and remediation (if needed) is considered established and the responsibility for further investigations lies with the landowners and the municipalities. No further initiatives from the national authorities are foreseen.

3.3.6.3 New initiatives

The following table indicates the new initiatives that will be taken in relation to the management of PFOS.

TABLE 26. New initiatives in relation to PFOS

No	Initiative	Description	Responsible institution	Timeframe
1	Withdrawal of notification	Withdraw notification of PFOS in mist suppressants for non-decorative hard chrome plating. Inform the Secretariat of the SC and the European Commission on Denmark's experience with the substitution of PFOS for this application.	MFVM	2018-2019
2	Waste incineration	Evaluate need for further initiatives based on the results of a desk study on destruction of PFOS and other POPs in MSW incinerators operating at a temperature of 850˚C.	MFVM	2019-2020

3.3.7 Notification requirements for exemptions concerning production and use of POPs covered by Annexes A and B

Denmark has not registered for specific exemptions regarding production and use of the 22 substances covered by the previous NIP. Denmark is not planning to apply for exemptions regarding production and use of the six newly added substances.

Until recently in Denmark, PFOS have been used for hard chromium plating (one of the acceptable uses) and the use has been notified as an acceptable use. For this application, PFOS has been replaced by an alternative which is not listed in the annexes to the Convention nor under evaluation for listing. Denmark is planning to withdraw the notification for this acceptable use.

3.3.8 Action plan for reduction of emission from unintentional formation of dioxins and other POPs

3.3.8.1 Implementation legislation

Requirements of the Convention on preparing national action plans to reduce unintentional formation of POPs have been implemented by the EU's POP Regulation. The existing legislation and the associated strategies for limiting releases of unintentionally formed POPs are summarised in section 2.2.5.5.

The POP Regulation requires Denmark and the other Member States to prepare and update inventories of releases of the substances listed in Annex III of the POP Regulation to air, water and soil. Moreover, Denmark and the other EU Member States must prepare and implement national action plans which are to identify, describe and minimise releases of such substances.

Currently, Annex C to the Convention includes the following substances: Dioxins (PCDD/PCDF), PCB, HCB, pentachlorobenzene, HCBD and PCNs.

3.3.8.2 Current issues

Dioxins intake with food. The most important intake of dioxin comes from food where the intake may still be disturbingly high. In some types of fish from the Baltic Sea and some other food items, the concentrations are still so high that they pose a risk for girls and women of childbearing age, as well as pregnant and breastfeeding women. These groups are consequently recommended to limit the intake of these food items. To be put on the market, the food items must comply with existing EU limit values.

Furthermore, a small percentage of the population shows dietary intake above the tolerable daily intake. EFSA is currently reassessing the risks of intake of dioxins and dioxin-like PCB and the results of the assessment are expected to be published by the end of 2018. On this basis, intake in Denmark will be reassessed.

Emission and releases of dioxins. Atmospheric emissions of dioxins in Denmark have been markedly reduced, as stated in section 2.3.11.1, which describes the trend in the releases by source category. In 2005, total Danish emissions from point sources were reduced to 6% of that of 1990, and by 2010, these were further reduced to 3.5% of the 1990 level. Since 2010, the total emissions have been rather stable with a small decrease in the releases from non-industrial combustion. Efforts from industry and waste incineration plants have meant that the emission from firing with biomass in private households and agriculture is now the highest national source of dioxin emission to the Danish environment. Combustion of wood and other biomass in small installations in private households and in agriculture represented 59% of the total Danish dioxin emissions in 2016. Accidental fires are the second-largest source at present, representing 23% of total Danish emission to air. The estimated emission from fires has been fairly stable as emission factors have not been changed; however, the calculation of emissions from fires is uncertain.

During the stakeholder consultation is has been questioned whether the emission factors applied for wood stoves and other residential biomass-fired heating systems reflect the actual releases from these sources. The emission factors are based on the EEA/EMEP (2016) guidebook for emission inventories undertaken as part of the reporting under the United Nations Economic Commission for Europe (UNECE) Convention on Long-Range Transboundary Air Pollution (CLRTAP). The Guidebook is published by the European Environment Agency (EEA) with the CLRTAP Task Force on Emission Inventories and Projections responsible for the technical content of the chapters. The emission factors were developed by an international expert group and the same factors were applied across the countries which are Parties to the CLRTAP. Two new Danish studies from 2017 and 2018 have not been able to confirm general low emission factors for modern eco-labelled wood stoves and indicate that the firewood used is of more importance for emissions (Schleicher, 2018; Andersen and Hvidbjerg, 2017). Furthermore, one of the studies shows a possible positive effect of rapid cooling of the flue gas in the stove. The studies call for more studies on the effect of using firewood with low content of chlorine and possibly copper compounds.

As mentioned above, the POP Regulation requires that release inventories should be drawn up and maintained for the substances listed in Annex III concerning releases into air, water and land in accordance with their obligations under the Convention and the POP Protocol. The EEA/EMEP guidebook does not include emission factors for releases to land and water as releases to these media are not addressed by the CLRTAP. For the dioxins, the most recent estimate of releases to water and land in Denmark was included in the substance flow analysis for dioxins from 2001.

During the stakeholder consultation it was noted that since the first national mass flow analysis on dioxins was published, both composition and locational patterns in Denmark of the main sources of dioxin have largely changed. Therefore, working out a new version of this kind of analysis with special reference to wood burning installations on all scales was recommended.

Emission and releases of HCB and PCB. The inventories of emission into air of HCB and PCB have been substantially improved since the latest NIP. Emission factors have been derived from the EEA/EMEP guidebook and emission factors and emission sources have been discussed in detail in a separate publication by DCE, the organisation responsible for the Danish inventory reporting (Nielsen *et al.*, 2014). Inventories of emissions of HCB and dioxin-like PCBs are included in the annual Danish emission inventory report for the UNECE Convention on Long-Range Transboundary of Air Pollution (CLRTAP).

The HCB emissions to air decreased markedly from about 45 kg in 1991 to about 10 kg in 1994 due to the phase-out of pesticides containing impurities of HCB. Total emission has further decreased to a level of 2.3 kg in 2016 (approximately 5% of the 1991 level). The main sources in 2016 were waste incineration plants and transport (diesel engines). No sources of HCB from the chemical industry or the metals industry in Denmark give rise to particularly high releases of these substances. No further activities specifically addressing HCB are foreseen.

The releases of dioxin-like PCBs are considerably higher than the estimated releases of HCB. The estimated releases of dioxin-like PCB have decreased from about 115 kg in 1990 to about 42 kg in 2016. The decrease is mainly due to the phase-out of leaded gasoline. The emission estimates include unintentionally produced PCB and do not include emissions to the environment from remaining PCB in building materials and electrical equipment. No data are available regarding emission due to the former intentional use of PCB in Denmark. The emissions are reported in mg/kg and not as dioxin equivalents in TEQ, making in interpretation of the results in terms of contribution for the dioxin-like PCB to the total dioxins load impossible. A complication in the comparison is that the emission factors for dioxins are in the I-TEQ unit, whereas only the WHO-TEQ system includes the dioxin-like PCB. An inventory from the UK demonstrates that it is possible to recalculate into a common unit and compare the emission of dioxins with the emission of dioxin-like PCB (Conolly *et al.*, 2009). The UK inventory furthermore includes releases to air, water and land for two substance groups and HCB.

Releases of pentachlorobenzene, HCBD and PCNs. The national emission inventories for the LRTAP do not include pentachlorobenzene, which is not listed under the UNECE POP protocol. A screening for data undertaken by DCE concluded that data are limited and national emissions inventories for pentachlorobenzene have not been undertaken. The screening concluded that the sources in Denmark would likely be the same as the sources of HCB.

No emission factors are available for pentachlorobenzene, HCBD and PCNs from the EEA/EMEP emission inventory guidebook used for the CLRTAP reporting.

For HCBD and PCNs no data are available. As the specific industrial processes that may lead to formation of HCBD do not take place in Denmark, the releases are considered small.

According to a risk profile for PCNs, waste incineration is the most important source of unintentionally formed PCNs, while other thermal processes possibly resulting in PCNs emissions are copper ore roasting, aluminium reclamation and chlor-alkali industry (van der Plassche and Schwegler, 2002). None of these processes take place in Denmark.

In order to assess whether some unexpected sources of HCBD and PCNs exist, which would call for further assessment, a screening of available data and sources in Denmark will be undertaken.

Wood-burning stoves. As shown in section 2.3.11.1, wood burning stoves and other domestic biomass-based heating systems comprise the main source of dioxin emission to the air in Denmark. These are also major sources in neighbouring countries; Swedish investigations reached the conclusion that non-industry combustion sources likely form the major current source of dioxins in air in the Baltic Sea. The dioxins and metal data could not even be used to pinpoint one combustion source category as more important than others.

The two previous NIPs have both included an activity addressing dioxin emission from wood stoves. The previous plan from 2012 had an action to "Monitor developments in relation to releases of POPs from wood-burning stoves".

The releases of dioxins and other POPs from the wood stoves can basically be reduced by two means: by use of wood stoves with lower emission of dioxins or by reducing the amount of wood burned.

As stated in the previous plan, initiatives taken to reduce releases of particles and PAH from wood-burning stoves have proven to have a poor effect on limiting dioxin releases. Initially, focus was on reducing particle releases as health impacts from particle releases from wood-burning stoves are assessed to be more substantial than the health impacts of dioxin releases.

The applied emission factors from the EEA/EMEP guidebook vary from 800 ng I-TEQ /GJ for old stoves to 100 ng I-TEQ /GJ for new eco-labelled stoves, indicating a high emission reduction potential in substituting the old stoves with new eco-labelled stoves. The low factor is based on a single Swedish study. The basis for the low emission factor has been questioned as part of the stakeholder consultation, as the emission factor has not been confirmed by other studies. During the stakeholder consultation it was suggested that the most efficient measure would be to reduce the amount of wood burned e.g. by the introduction of a tax on wood burning, which could possibly vary by location and type of stove. Introduction of a tax was considered by the Danish Government in 2017 but a tax is not currently supported by a majority in the Parliament.

In Denmark it is decided to allocate 45 million DKK in 2019 for a wood stove scrapping bonus programme for old stoves before 1994 in order to reduce the releases of pollutants from stoves. Furthermore, The Danish Government has suggested that wood stoves installed before 2000, must be closed or replaced when a house, summerhouse or apartment exchanges hands, starting in 2020. Both initiatives may result in decreased use of firewood because new stoves are more efficient and some fireplaces may be closed; consequently, a decrease in total emission from the stoves would be expected.

Flue gas cleaning residues. The use of effective flue-gas cleaning for point sources means that most of the dioxin and other POPs end up in flue-gas cleaning products. Until now, the products have been landfilled outside Danish borders in Germany and Norway. The two previous NIPs have included actions addressing flue gas cleaning residues from waste incineration.

The ongoing LIFE HALOSEP project with participation of the Danish MSW incinerator I/S Vestforbrænding aims at developing a process where the residues can be treated so they do not need to be disposed of as hazardous waste. The project runs until the end of 2019.

The progress of that project will be followed by the MFVM and, on the basis of the results, it will be assessed whether further activities should be initiated and whether changes should be made to the legislation on disposal of flue-gas cleaning products.

3.3.8.3 New initiatives

The following table indicates the new initiatives that will be taken in relation to the reduction of formation and emission of dioxins and other unintentionally formed POPs.

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TABLE 27. New initiatives in relation to dioxins and other unintentionally produced POPs

No	Initiative	Description	Responsible institution	Timeframe
1	Reducing emissions from wood stoves and residential biomass-based heating systems	Inform users to use clean and dry wood and not to burn waste in wood stoves in future campaigns	MFVM	2019-2020
2	Improve emission inventories	Undertake screening surveys for emissions of HCBD and PCNs	MFVM	Continually
3	Follow the development of new methods for management of flue gas cleaning residues	Follow the progress of the HALOSEP project and, on the basis of the results, assess whether further activities should be initiated and whether changes should be made to the legislation on disposal of flue-gas cleaning products.	MFVM	2020- continually

3.4 Implementation of other obligations under the Convention

3.4.1 Listing of new chemical substances in Annexes A, B and C

3.4.1.1 Status

Denmark would generally like to see relevant POPs covered by international regulation.

The three substances currently under consideration and their respective uses are briefly described in the following table.

TABLE 28. Substances proposed for listing under the Stockholm Convention

Substance	CAS no.	Use of the substance*	Use in Denmark
Dicofol	115-32-2	Pesticide that has been used in agriculture to control mites on a variety of field crops, fruits, vegetables, ornamentals, cotton, and tea.	Used until 1993. Quantities used 1991-1993 ranged from 283 to 655 kg/year
Pentadecafluorooctanoic acid (PFOA) its salts and PFOA-related compounds	335-67-1 (PFOA)	Used in the production of fluoroelastomers and fluoropolymers for the production of non-stick kitchenware and food processing equipment. PFOA-related compounds, including side-chain fluorinated polymers, are used as surfactants and surface treatment agents in textiles, paper and paints, and firefighting foams. Unintentional formation of PFOA is created from inadequate incineration of fluoropolymers from MSW incineration with inappropriate incineration or open burning facilities at moderate temperatures.	No current or historical use in Denmark registered in the SPIN database. The main issue with regard to PFOA is to what extent some fluorotelomers and side-chain fluorinated polymers may contain perfluorinated moieties that may be precursors for PFOA when the substances degrade (Lassen *et al.*, 2013,b) PFOA has been found in measurable concentrations in municipal wastewater, in environmental samples of sediments and biota, in food and in human blood and human milk (Lassen *et al.*, 2013,b)
Perfluorohexane sulfonic acid, its salts and PFHxS-related compounds	355-46-4 (PFHxS)	PFHxS, its salts and related compounds are used in a variety of consumer goods such as carpets, leather, apparel, textiles, firefighting foam, papermaking, printing inks, sealants and non-stick cookware.	No current or historical use in Denmark registered in the SPIN database. A recent Norwegian study indicates that current production takes place in China. The main issue appears to be trace content of PFHxS in various treated articles and fire-fighting foams PFHxS has been found in measurable concentrations in soil sewage sludge, wastewater, in environmental samples of sediments and biota, in human blood and human milk (Lassen *et al.*, 2013,b)

* Source: UNEP website at:
http://chm.pops.int/TheConvention/ThePOPs/ChemicalsProposedforListing/tabid/2510/Default.aspx

3.4.2 Exchange of information with other Parties and information to the public

3.4.2.1 Status
The provisions of the Convention on exchange of information with other Parties, information to the public, etc. are incorporated into Article 10 of the POP Regulation. Current activities regarding information to the public and exchange of activities are described in section 2.3.15.

3.4.2.2 New initiatives
Denmark will continue to exchange information with the other Nordic countries and participate in the ongoing exchange of information with the other EU Member States.

In future, Danish research institutions will cooperate with research institutions in other Member States on a number of EU-funded research projects related to POPs.

Knowledge about POPs will primarily be communicated along with knowledge about other substances hazardous to health and the environment. All results of monitoring of POPs in the environment and in food and animal feed, emissions inventories, and reviews, investigations and studies on POPs will continue to be published on the websites of the Danish EPA and other relevant institutions, and, thus, be available to the public.

3.4.3 Research, development and monitoring

3.4.3.1 Status
Current monitoring initiatives are described in section 2.3.14. Current research activities are described in section 2.3.17.1. Research is carried out with funds from many different sources.

3.4.3.2 New initiatives
The Danish Nature Agency and the Danish Centre for Environment and Energy (DCE) at Aarhus University will continue to monitor POPs in the environment.

The MFVM will continue its work to support research initiatives taken to investigate the presence of POPs in the Arctic environment and their impact on animals and humans. Investigations include POPs already covered by the Stockholm Convention, as well as potential candidates for inclusion under the Convention.

Monitoring and research activities will, to a great extent, be carried out in cooperation with other Parties to the Convention.

3.4.4 Technical and financial assistance to other countries

3.4.4.1 Status
Implementation legislation: The provisions on technical assistance are incorporated into Article 11 of the POP Regulation which includes the general obligation of the Commission and Member States to provide technical assistance to developing countries and countries in transition. This assistance may also be provided through non-governmental organisations.

Technical assistance provided so far. Danish support to POP-related activities will primarily be channelled through the Global Environmental Facility, GEF, which has been appointed as the financial mechanism for the Stockholm Convention. For the period 2014-2018, Denmark contributed DKK 435 million (EUR 57 million) to these efforts. GEF has six main focus areas: climate change, biodiversity, international waters, land degradation, forests, and chemicals and waste (including the POPs).

In addition, as a party to the Convention, Denmark has contributed to the operation of the Stockholm Convention (the general trust fund for the Convention); the amount is DKK 200,000-250,000 per year (EUR 27,000- 33,000 per year).

Denmark provides support through its commitments in NEFCO, Nordic Environment Finance Cooperation, to projects in Russia, Ukraine and the Baltic countries involving, among other topics, PCB, dioxin and disposal of POP pesticides.

Through its general contributions to the EU budget, Denmark also contributes to EU environment work in developing countries and countries in transition, of which some deal with POP problems.

3.4.4.2 New initiatives

Danish support to POP-related activities will continue to be channelled primarily through GEF, which is the appointed financial mechanism for the Stockholm Convention. Furthermore, Denmark will contribute to the operations of the Stockholm Convention secretariat.

3.4.5 Costs and effectiveness

3.4.5.1 Costs

Additional costs relating to Denmark's accession to the Stockholm Convention are considered linked primarily to Denmark's contribution to the functioning of the Convention (contribution to the Secretariat), as well as the financing mechanism (GEF).

This is because the majority of the measures required to meet the commitments under the Convention have already been taken and, furthermore, because for many years POPs have had a high priority in Denmark, and form an integral part of current monitoring and research programmes.

Major elements of costs relating to ongoing POP-related activities (including activities that go beyond the requirements of the Convention) are:

- Mapping of PCB in building materials by renovation and demolition of buildings as required by the statutory order on waste and on indoor air (costs primarily paid by public and private building owners);
- Mitigation measures to reduce PCB concentrations in indoor air (costs primarily paid by public and private building owners);
- Selective demolition of buildings and disposal of waste containing PCB and any decontamination of sites contaminated with PCB (costs primarily paid by public and private building owners);
- Establishing installations to reduce releases of dioxin and other unintentionally formed POPs at new incineration plants;
- Maintenance and operation of existing installations to reduce emissions of dioxin and other unintentionally formed POPs, and disposal of residues from flue-gas cleaning;
- Monitoring of POPs in emissions, in the environment, in foodstuffs, and in animal feed;
- Ban on fish with excessive levels of dioxins, and
- Programmes to investigate the presence and impacts of substances with POP properties on humans and in the environment.

The last NIP indicated that the overall costs, until all PCB-containing materials have been removed, may be on the order of several billion DKK. This estimate remains valid. The annual cost for PCB remediation is not known. The disposal costs of PCB-containing building waste in recent years may be estimated to be on the order of 10-20 million DKK/year; this only represents a minor part of the total costs of PCB remediation. The costs of PCB surveys in buildings and the management of the materials may likely be significantly higher than the disposal costs.

Compared to the costs of management of PCB in building materials, the additional costs of management of SCCPs in building materials are considered minor because the quantities of materials contaminated at levels above 10,000 mg/kg are small as compared with the quantities of materials contaminated with PCB at a level above the limit of 50 mg/kg.

3.4.5.2 Effectiveness

Each Party shall report to the Conference of the Parties on the measures it has taken to implement the provisions of this Convention and on the effectiveness of such measures in meeting the objectives of the Convention.

3.5 Timetable

The implementation plan will be carried out according to the timetable below.

TABLE 29. Timetable for implementing new initiatives

Substance/ Area	No	Initiatives	Time frame
DecaBDE and other PBDEs	1	Undertake control of products on the Danish market. Assess how materials with PBDEs can be separated from the waste stream prior to recovery and other waste treatment. Prepare advice for recycling companies	Continually
SCCPs	1	Evaluate the need for further information on SCCP-waste to contractors, property owners, municipalities, and other stakeholders involved in activities related to building renovation and demolition. If the evaluation demonstrates the need for further information, the MFVM will prepare it accordingly.	2019-2020
HBCDD	1	Assess whether selective sorting with the aim of destruction of EPS and XPS with HBCDD should be required on the basis of an evaluation of the efficiency of incineration of HBCDD in MSW incinerators.	2019-2020
	2	Evaluate the need for further information for contractors, property owners, municipalities, and other stakeholders involved in activities related to building renovation and demolition on identification and handling of HBCDD-waste. If the evaluation demonstrates the need for further information, the MFVM will prepare the required guidelines.	2019-2020
PCB	1	Finalise current study on PCB in transformers and capacitors and evaluate if further initiatives are needed	2019-2020
	2	Follow the results of the ongoing HESPERUS project, which assesses the risk of low-chlorinated PCB in the indoor environment. Assess to what extent further actions would be needed based on the results of the project.	2019-2022
	3	Revisit the assessment of destruction efficiency for PCB along with results of the ongoing assessment of efficiencies for other POPs. Assess, on this basis, the need for further initiatives	2019-2020
PFOS	1	Withdraw notification of PFOS in mist suppressants for non-decorative hard chrome plating. Inform the Secretariat of the SC and the European Commission on Denmark's experience with the substitution of PFOS for this application	2018-2019
	2	Evaluate the need for further initiatives based on the results of a desk study on destruction of PFOS and other POPs in MSW incinerators operating at a temperature of 850˚C.	2019-2020

Dioxins and other uninten-tionally formed POPs	1	Inform users to use clean and dry wood and not to burn waste in wood stoves in future campaigns	2019-2020
	2	Undertake screening surveys for emissions of HCBD and PCNs	Continually
	3	Follow the progress of the HALOSEP project and, on the basis of the results, assess whether further activities should be initiated and whether changes should be made to the legislation on disposal of flue-gas cleaning products.	2020- continually

4. Abbreviations and measurement units

4.1 Abbreviations

ABS	Acrylonitrile butadiene styrene
ACAP	Arctic Contaminants Action Program (ACAP)
AFFF	Aqueous fire-fighting foams
AMAP	Arctic Monitoring and Assessment Programme
BAT	Best available techniques
BDE#209	DecaBDE
DecaBDE	Decabromodiphenyl ether
BEP	Best Environmental Practice
BFR	Brominate flame retardant
BREF	BAT Reference (...documents)
CAS	Chemical Abstract Service [identification number for chemicals]
c-DecaBDE	Commercial Decabromodiphenyl ether (mixture of PBDEs; nearly 100% decaBDE)
CLRTAP	UNECE Convention on Long-range Transboundary Air Pollution
CLP	Classification, labelling and packaging
CMR	Carcinogenic, mutagenic or toxic for reproduction
COP	Conference of the Parties
c-OctaBDE	Commercial octabromodiphenyl ether (mixture of PBDEs)
CONTAM	EFSA Panel on Contaminants in the Food Chain
c-PentaBDE	Commercial pentabromodiphenyl ether (mixture of PBDEs)
DAKOFA	The Danish Competence Centre on Waste
DCE	Danish Center for Environment and Energy
DDE, DDD	Degradation products of DDT
DDT	1,1,1-trichloro-2,2-bis(4-chlorophenyl)ethane
DecaBDE	Decabromodiphenyl ether the commercial products in designated c-decaBDE
Dioxins	Used as abbreviation for polychlorinated dibenzo-*p*-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF)
DKK	Danish kroner
DPA-system	Danish Producer Responsibility System
DVFA	Danish Veterinary and Food Administration
EAC	Environmental Assessment Criteria
EBTEBPI	Ethylene bis(tetra-bromophthalimide)
EC	European Community
ECHA	European Chemicals Agency
EEE	Electrical and electronic equipment
EEA	European Environment Agency
EFSA	European Food Safety Authority
EMEP	European Monitoring and Evaluation Programme (EMEP)
E-PRTR	European Pollutant Release and Transfer Register
EPA	Environmental Protection Agency
EPDM	Ethylene propylene diene monomers
EPS	Expanded polystyrene
EU	European Union
EVA	Ethylene vinyl acetate
EQS	Environmental Quality Standard

FSAI	Food Safety Authority of Ireland
GDP	Gross domestic product
GEF	Global Environment Facility
GRUMO	Groundwater monitoring programme
HBCDD	Hexabromocyclododecane (also abbreviated HBCD)
HCB	Hexachlorobenzene
HCBD	Hexachlorobutadiene
HCH	Hexachlorocyclohexane, three forms: α, β and γ
HELCOM	Helsinki Commission
HIPS	High impact polystyrene
HexaBB	Hexabromobiphenyl
HeptaBDE	Heptabromodiphenyl ether
HexaBDE	Hexabromobiphenyl ether
HIPS	High-impact polystyrene
LOD	Limit of detection
LOUS	The Danish EPA's List of Undesirable Substances (Listen over uønskede stoffer)
LOQ	Limit of quantification
MCCPs	Medium-chain chlorinated paraffins
MFVM	Ministry of Environment and Food of Denmark
MoS	Margin of Safety
MSW	Municipal solid waste
NEFCO	Nordic Environment Finance Cooperation
NGO	Non-governmental organisation
NIP	National Implementation Plan [for the Stockholm Convention]
NMC	National mean concentration
NOEL	No Observable Effect Level
NOVA	The national programme for monitoring the aquatic environment and nature, until 2003
NOVANA	The national programme for monitoring the aquatic environment and nature
OctaBDE	Octabromodiphenyl ether
OECD	Organisation for Economic Cooperation and Development
OSPAR	The Convention for the Protection of the Marine Environment of the North-East Atlantic
PAH	Polyaromatic hydrocarbons
PBB	Polybrominated biphenyls
PBDD	Brominated dibenzo-p-dioxins
PBDE	Polybrominated diphenyl ether
PBFD	Brominated dibenzo furans
PBT	Persistent, bioaccumulative and toxic
PCB	Polychlorinated biphenyls
PCDD	Polychlorinated dibenzo-*p*-dioxins
PCDF	Polychlorinated dibenzofurans
PCNs	Polychlorinated naphthalenes
PCP	Pentachlorophenol
PCT	Polychlorinated terphenyls
PE	Polyethylene
PeCB	Pentachlorobenzene
PentaBDE	Pentabromodiphenyl ether
PFAA	Perfluorinated alkyl acid
PFAS	Per- and polyfluoroalkyl substances
PFC	Perfluorinated compounds [used in citations - more or less identical to PFAS]
PFCA	Perfluoroalkyl carboxylic acids
PFHxS	Perfluorohexane sulfonic acid/sulfonate (and its derivatives)

PFOA	Perfluorooctanoic acid (and its derivatives)
PFOS	Perfluorooctane sulfonic acid/sulfonate (and its derivatives) (in the Stockholm Convention, PFOS only covers perfluorooctane sulfonic acid)
PFOSF	Perfluorooctanesulfonyl fluoride
PFSA	Perfluoroalkyl sulfonic acids
PIC	Prior informed consent (refers to the principle laid down in the Rotterdam Convention on prior informed consent)
PNEC	Predicted No-Effect Concentration
POP	Persistent organic pollutant
PP	Polypropylene
PPE	Polyphenylene ether
PPO/PS	Polyphenylene oxide/polystyrene
PRTR	Pollutant Release and Transfer Register (register of releases and transfer of pollutants)
PVC	Polyvinylchloride
PXDD/PXDF	Mixed polybrominated and polychlorinated dioxins and furans
RASFF	Rapid Alert System for Food and Feed
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals (Regulation (EC) No 1907/2006)
RCR	Risk Characterisation Ratio
RoHS	Restriction of Hazardous Substances (...in electrical and electronic products) Directive 2002/95/EC
SAICM	Strategic Approach to International Chemicals Management
SBR	Styrene-butadiene rubber
SCCPs	Short-chain chlorinated paraffins
TBBPA	Tetrabromobisphenol A
TCP	Tetrachlorophenol
TDI	Tolerable Daily Intake
TEF	Toxicity equivalency factor (for dioxins and dioxin-like PCBs)
TEQ	Dioxin toxicity equivalents (for dioxins and dioxin-like PCBs)
TOC	Total organic carbon
TPU	Thermoplastics polyurethane
TWI	Tolerable Weekly Intake
UK	United Kingdom
UNECE	United Nations Economic Commission for Europe
UPS	Unsaturated polystyrene
US EPA	United States Environmental Protection Agency
vPvB	Very persistent and very bioaccumulative
WEEE	Waste electrical and electronic equipment
WHO	World Health Organisation
WWTP	Waste water treatment plant
XPS	Extruded polystyrene
#	# is used for notation of congeners where congeners are numbered according to international nomenclature

4.2 Units of measurement

I-TEQ	Unit expressing total toxicity of PCDD and PCDF in a sample weighted on the basis of the “international” toxicity-weighting system for toxicity of individual types of dioxin
WHO-TEQ	Unit expressing total toxicity of PCDD, PCDF and dioxin-like PCBs in a sample weighted on the basis of the WHO toxicity-weighting system for toxicity of individual types of dioxin. The weighing has changed over time. The version from 2005 is indicated as WHO-TEQ_{2005}
PCB_{total}	Usually calculated as 5 x PCB_6 or 5 x PCB_7

PCB_7	The sum of 7 indicator PCB: PCB#28, PCB#52, PCB#101, **PCB#118,** PCB#138, PCB#153 and PCB#180 (PCB#118 is a dioxin-like PCB)
PCB_6	The sum of 6 indicator PCB: PCB#28, PCB#52, PCB#101, PCB#138, PCB#153 and PCB#180
dw	Dry weight
l.w.	Lipid weight
mg	milligram = 10^{-3} g
µg	microgram = 10^{-6} g
ng	nanogram = 10^{-9} g
pg	picogram = 10^{-12} g
fg	femtogram = 10^{-15} g
Nm^3	Normal cubic metre
Tonne	1000 kg
ww	Wet weight

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Annex 1 Maximum concentration limits of substances listed in Annex IV to the POPs regulation

Annex V Waste Management to Regulation (EC) No 850/2004, Part 2.

Substance	Maximum concentration limits of substances listed in Annex IV(1)
Alkanes C10-C13, chloro (short-chain chlorinated paraffins) (SCCPs)	10,000 mg/kg
Aldrin	5,000 mg/kg
Chlordane	5,000 mg/kg
Chlordecone	5,000 mg/kg
DDT (1,1,1-trichloro-2,2-bis (4-chlorophenyl) ethane)	5,000 mg/kg
Dieldrin	5,000 mg/kg
Endosulfan	5,000 mg/kg
Endrin	5,000 mg/kg
Heptachlor	5,000 mg/kg
Hexabromobiphenyl	5,000 mg/kg
Hexabromocyclododecane	1,000 mg/kg
Hexachlorobenzene	5,000 mg/kg
Hexachlorobutadiene	1,000 mg/kg
Hexachlorocyclohexanes, including lindane	5,000 mg/kg
Mirex	5,000 mg/kg
Pentachlorobenzene	5,000 mg/kg
Perfluorooctane sulfonic acid and its derivatives (PFOS) ($C_8F_{17}SO_2X$) (X = OH, Metal salt (O-M+), halide, amide, and other derivatives including polymers)	50 mg/kg
Polychlorinated Biphenyls (PCB)	50 mg/kg
Polychlorinated dibenzo-p-dioxins and dibenzofurans	5 mg/kg
Polychlorinated naphthalenes	1,000 mg/kg
Sum of the concentrations of tetrabromodiphenyl ether $C_{12}H_6Br_4O$), pentabromodiphenyl ether ($C_{12}H_5Br_5O$), hexabromodiphenyl ether ($C_{12}H_4Br_6O$) and heptabromodiphenyl ether $C_{12}H_3Br_7O$)	10,000 mg/kg
Toxaphene	5,000 mg/kg.

[Bagside Overskrift]
[Bagside Tekst]

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