Consultation response to the Proposed Exemptions of PFOA related substances by the POPs Review Committee, representing the Stockholm Convention.

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ERM

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Contents

1 EXECUTIVE SUMMARY

This report has been prepared by Environmental Resources Management Limited (ERM) on behalf of a European based company who seeks a time limited exemption until 4 July 2023, for the use of PFOA-related substances in the coating of electronic items and other products using plasma polymerisation, when they are listed under the Stockholm Convention. This is an additional exemption to those already recommended by the POPs Review Committee[1] and would align with the restriction exemption for "plasma nano-coating" that was included in Annex XVII to Regulation (EC) No 1907/2006:

'68. Perfluorooctanoic acid (PFOA) CAS No 335-67-1 EC No 206-397-9 and its salts. Any related substance (including its salts and polymers) having a linear or branched perfluoroheptyl group with the formula C_7F_{15}- directly attached to another carbon atom, as one of the structural elements. Any related substance (including its salts and polymers) having a linear or branched perfluorooctyl group with the formula C_8F_{17}- as one of the structural elements. The following substances are excluded from this designation: — C8F17-X, where X = F, Cl, Br. — C_8F_{17}-C(=O)OH, C_8F_{17}-C(=O)O-X′ or C_8F_{17}-CF_2-X′ (where X′ = any group, including salts).	1. Shall not be manufactured, or placed on the market as substances on their own from 4 July 2020. 2. Shall not, from 4 July 2020, be used in the production of, or placed on the market in: (a) another substance, as a constituent; (b) a mixture; (c) an article, in a concentration equal to or above 25 ppb of PFOA including its salts or 1 000 ppb of one or a combination of PFOA-related substances. **3. Points 1 and 2 shall apply from:** **(b) 4 July 2023 to:** (i) textiles for the protection of workers from risks to their health and safety; (ii) membranes intended for use in medical textiles, filtration in water treatment, production processes and effluent treatment; **(iii) plasma nano-coatings.**

A major use of this technology is in the protection of electronic devices. As part of the EU consultation that preceded the introduction of this exemption, the company presented a socio-economic analysis of the effect of the non-use of the PFOA related substance which would be placated by an exemption for the use until 4 July 2023 after which time the company would have moved to an alternative chemistry offering equal performance and functionality. This socio-economic analysis has been updated to present the case for an exemption under the UN Stockholm Convention for the use in plasma nano coating. Please note that the majority of the monetary figures in this report are presented as Euros (€) throughout.

[1] http://chm.pops.int/TheConvention/POPsReviewCommittee/Meetings/POPRC14/Overview/tabid/7398/Default.aspx

[2] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32017R1000&from=EN

This document presents the socio-economic impact in the context of requesting an exemption until 2023 for the continued use of PFOA-related substances in plasma nano-coating under the UN Stockholm Convention[2]. This would allow the continued use of the company's nano-coating process, worldwide, up until 2023. A period of less than this would not allow it enough time to complete on-going research into, and commercial implementation of, viable alternatives.

The electronic product protection process involves plasma polymerising a C8F17-X monomer into a highly water- and oil-repellent coating. Unfortunately, this monomer, as well as any other alternatives with C8F17-X side chains, falls within the proposed POPs ban as a perfluorooctanoic acid (PFOA)-related substance.

Depending on the required water and oil repellency performance, or electrically insulating coating performance, of the product, the coatings currently vary in thickness between 2nm and 4µm (although could go thicker depending on the protection requirements). The polymer coating has a very low surface energy and so imparts properties of water- and oil-repellence (hydro- and oleo-phobicity) to any treated product. This increases the performance, reliability and durability of the products and decreases failure replacement costs to the manufacturer.

This European based technology company has been repeatedly recognised for its innovative product solutions and rapid market growth. It currently has 137 employees; 90 in Europe and 47 in the Rest of the World. It is committed to continuous improvement in the environmental performance of its manufacturing processes and its products.

To this end, the company has screened commercially available substances in search of comparable performance profiles to the C8F17-X monomer. It has potentially found an alternative chemistry, however further research and development is required in order to make the transition to established commercial process. The key issue is that improvements need to be made in the process using alternative chemistry as the coating process currently takes longer; the production time needs to be reduced to obtain a similar throughput as the existing technology in order to fit in the assembly lines of the world's largest electronic manufacturers. The changes to meet customer demands related to throughput have made it challenging for the alternative chemistry process to be an easy transition. And this is at a time when demand is increasing as market research has shown that consumers value durability highly in their electronic devices, a key element of which is water and oil repellency of the level provided by this technology.

In addition to its first choice of alternative chemistry, the company has also considered the suggested alternative substances for surface coatings (such as siloxanes and silicone polymers, propylated aromatics, sulfosuccinates, fatty alcohol polyglycol ether sulfate, and alykl acrylates), in terms of their potential as replacements, however, these are not considered to be the most suitable alternatives for this application. The company's first choice of alternative chemistry material is currently considered to be the most viable alternative, in favour of the suggested options, however, due to the above-mentioned limitations, further research is required in order to ensure its satisfactory levels of throughput to meet demand.

If the transitional period of the C8F17-X monomer as a PFOA-related substance, proposed by the POPS Review Committee does not align with that included in Annex XVII to Regulation (EC) No 1907/2006 this would have a significant economic impact upon the company, its suppliers, customers and end-consumers of coated products, as well as an adverse environmental impact in terms of electronic device durability and a more frequent need to replace them.

The socio-economic impacts presented in this report are focused on the company's primary markets in the electronic product sector.

ERM estimates that the socio-economic impacts of the proposed ban over a 5 year time period for the company's largest electronic product market would be:

- Total replacement costs of damaged products to European consumers between 2019 and 2023 of €642m net present value (NPV).
- A loss of direct economic costs between 2019 and 2023 of €295m NPV triggered by a loss of €14m profit/
- A loss in direct revenue of upstream suppliers between 2019 and 2023 of €15m NPV; and
- A loss of annual earnings to the EU employees due to long term unemployment between 2019 and 2023 of €0.24m NPV.

The total NPV costs of the proposed ban would be in excess of **€0.95** billion.

ERM's outline environmental assessment has found the impacts associated with treating a product with the company's polymer coating to be negligible when compared with benefits that the coating provides. Across the product life cycle of electronic products, which constitutes 78.1% of the company's market, ERM draws the following conclusions.

- The material emissions associated with treating electronic products are negligible, adding less than 1% to total production emissions.
- A high proportion of electronic products would go through a closed loop recycling process in line with the EU WEEE Directive and similar directives globally.
- The company's polymer coating would thermally decompose during the recovery of materials in the smelting process or during municipal waste incineration.

- There are significantly greater quantities of precious metals contained within a typical electronic product – 34mg gold and 340mg silver compared to approximately 3mg of C8F17-X polymer coating. These precious metals should be recovered in addition to the critical raw materials. [1].
- If the product was landfilled, the approximate half-life of the polymer coating is in the range of 33 to 112 years before it degrades into a fluorotelomer alcohol. However, the likelihood of this occurring is especially low for electronic products due to the requirements of the WEEE Directive and the small amount of coating on the product.

For the company's main market of electronic products, the greatest proportion of the environmental impacts across the life cycle are associated with production. The polymer coating protects the electronic product from corrosion and water damage, resulting in greater reliability and durability. The potential environmental benefits associated with the 44 million electronic products treated by the company in 2018 alone, as a result of avoided water damage failure were:

- over 800 thousand damaged products prevented from being returned to the manufacturer, with subsequent end of life management obligations;
- over 42,000 tonnes of CO_2e production emissions associated with replacement products avoided, which is equivalent to the annual emissions of 9,000 cars; and
- a potential reduction of over 6600 tonnes of high-value hazardous electronic waste.

If all 1.44+ billion electronic products shipped worldwide in 2018 had the polymer nano-coating in the future, the estimated annual waste and carbon savings would equate to:

- over 27 million products prevented from being returned annually to the manufacturers with consequent end of life management obligations;
- more than 1.4 million tonnes of CO_2 saved each year through reduced production emissions, equivalent to the annual energy consumption of more than 120,000 households [2]

Across the product life cycle of consumer electronic products, which constitutes 78.1% of the company's market, ERM draws the following conclusions.

[1] http://ec.europa.eu/growth/sectors/raw-materials/specific-interest/critical_en

[2] http://www.epa.gov/cleanenergy/energy-resources/calculator.html#results

As consumer electronic devices become more embedded and ubiquitous in society, there is a growing trend in the industry for IPx7 level performance. This requires of an electrical device that it is still able to function when being submerged under one metre depth of water for a minimum of 30 minutes [1]. The polymer coating provides this level of performance without the need for manufacturers to design and use components such as rubber O-rings, membranes and gaskets. At the end of the devices's life cycle these components do not have a high value – containing no precious metals and would have to go to landfill or municipal waste incineration. The polymer coating does not require all these additional components to be either manufactured or disposed, which reduces the environmental impact associated with the production of the electronic device.

Concluding Statement

We believe that the socio-economic impacts evaluated above justify a transitional period from the POPs Review Committee, of up until July **2023**, in relation to the proposed time limited exemptions of PFOA related substances, proposed by the POPs Review Committee. This would align with the transitional period included in Annex XVII to Regulation (EC) No 1907/2006. This would allow the company enough time to research, develop, and implement suitable and efficacious alternatives to the C8F17-X monomer.

Alignment of the transitional periods, to 2023, would maintain business continuity and ensure the company's projected future growth is achievable, with its associated socio-economic benefits.

ERM's outline environmental assessment has found the impacts associated with treating a product with the company's polymer coating to be negligible when compared with benefits that the coating provides. ERM therefore does not believe that it would be environmentally damaging to continue to use the C8F17-X monomer until 2023, when the monomer will be replaced with an alternative. Conversely, it would be more environmentally damaging to issue a ban prior to 2023, before a suitable alternative would be in place, as there would be increased water damage to electronics devices, which would result in higher damage and return rates. This would cause increases in the number of devices going to landfill or waste reclamation, and increases in repair operations, which would result in a higher associated carbon footprint.

[1] http://www.nema.org/Standards/ComplimentaryDocuments/ANSI-IEC-60529.pdf

2 *INTRODUCTION*

Environmental Resources Management Limited (ERM) is preparing a response to the proposed exemptions of PFOA related substances by the POPs Review Committee. The aim of ERM's response is to make the case of alignment of transitional period from the POPs Review Committee, with included in Annex XVII to Regulation (EC) No 1907/2006, of up until 2023, in order to allow companies to adequately address suitable alternatives.

The response sets out the socio-economic impacts, chemicals risks, and environmental case for allowing an appropriate amount of time to research and implement alternatives to the C8F17-X monomer used by the company.

In June 2015, the European Union (EU) and its member States submitted a proposal to list pentadecafluorooctanoic acid (CAS No: 335-67-1, PFOA, perfluorooctanoic acid), its salts and PFOA-related compounds in Annex A, B, and/or C of the Stockholm Convention (UNEP/POPS/POPRC.11/5). The Committee concluded that PFOA fulfilled the screening criteria in Annex D and that issues related to the inclusion of PFOA-related compounds that potentially degrade to PFOA and the inclusion of PFOA salts should be addressed in the draft risk profile (see decision POPRC-11/4).

The substances covered by the risk profile are PFOA including its isomers, its salts and PFOA-related compounds which includes C8F17-X monomer which is used by some companies in plasma nano coating.

The Committee decided to recommend to the Conference of the Parties that it consider listing pentadecafluorooctanoic acid (CAS No: 335-67-1, PFOA, perfluorooctanoic acid), its salts and PFOA-related compounds in Annex A or B to the Convention with specific exemptions for the following:

(a) For five years from the date of entry into force of the amendment in accordance with Article 4:
(i) Manufacture of semiconductors or related electronic devices:
a. Equipment or fabrication plant related infrastructure containing fluoropolymers and/or fluoroelastomers with PFOA residues;
b. Legacy equipment or legacy fabrication plant related infrastructure: maintenance;
c. Photo-lithography or etch processes;
(ii) Photographic coatings applied to films;
(iii) Textiles for oil and water repellency for the protection from dangerous liquids for the protection of workers from risks to their health and safety;
(b) For ten years from the date of entry into force of the amendment for manufacture of semiconductors or related electronic devices: refurbishment parts containing fluoropolymers and/or fluoroelastomers with PFOA residues for legacy equipment or legacy refurbishment parts;

(c) For use of perfluorooctane iodide, production of perfluorooctane bromide for the purpose of producing pharmaceutical products with a review of continued need for exemptions. The specific exemption should expire in any case at the latest in 2036.

None of these uses cover coatings by plasma polymerisation.

In early 2018, parties and observers, including the relevant industries, were invited to provide, information that would assist the possible defining by the Committee of specific exemptions for production and use of PFOA, its salts and PFOA-related compounds in particular in the following applications:

(a) Membranes intended for use in medical textiles, filtration in water treatment, production processes and effluent treatment: information on the scope of the applications, used amounts, availability of alternatives and socio-economic aspects;
(b) Transported isolated intermediates in order to enable reprocessing in another site than the production site: information on the quantities used, extent of transport and risks, and use;
(c) Medical devices: information on specific applications/uses and timelines foreseen as needed for potential related exemptions;
(d) Implantable medical devices: information on the quantities used, extent of transport and risks, and use;
(e) Photo imaging sector: information on paper and printing, and information relevant for developing countries;
(f) Automotive industry: information on spare parts;
(g) Firefighting foams: information on chemical composition of mixtures and the volumes of pre-installed amount of firefighting foam mixtures.
For the applications above, information regarding socio-economic aspects as well as other relevant information is also welcomed.

Furthermore, Parties and observers were invited to provide information that would assist the further evaluation by the Committee of pentadecafluorooctanoic acid (CAS No: 335-67-1, PFOA, perfluorooctanoic acid), its salts and PFOA-related compounds in relation to its unintentional formation and release, in particular from primary aluminium production and from incomplete combustion.

Plasma polymerisation is not covered in the Committee's proposed exemptions nor has any further information been sought on this use or the reasons why a time limited exemption was included in Annex XVII to Regulation (EC) No 1907/2006. A European based company wishes to provide this background information and to request a transitional period of up until 4 July 2023, in order to allow it to continue with the monomer's use, (in plasma polymerisation) in line with the time limited exemption granted in the EU.

The company's process provides a step change in environmental performance over conventional solution-based applications of these chemistries. By using a vacuum-based process, it uses tiny quantities of starting monomer, and with no requirement for solvents or water, it produces negligible waste and has no post-curing treatments.

2.1 *OUTLINE SOCIO-ECONOMIC ASSESSMENT*

In the socio-economic section of this report, ERM estimates the impacts that a ban on PFOA and PFOA-related substances would have in terms of direct economic costs to the company, social costs to employees and indirect upstream and downstream costs along the supply chain. In addition, based on the nano-coating's primary function of enhancing the performance of products, ERM has assessed the impacts of the proposed ban to the end consumer in terms of reduced product quality, replacement costs and their environmental costs.

The technology employed is a novel one and the full commercial and social potential of the company's innovation is still to be fully realised. It is an important principle of regulation that innovation that will deliver future economic, social and environmental benefits is not stifled. The company has been recognised its product innovation winning numerous business awards in Europe and Asia.

In this section of the report, we provide an explanation of the growth prospects for the company's technology, both with respect to its existing market and in relation to how its solutions could be used in further applications in the future.

Annual sales projections provided by the company show expected growth of over 140% between 2018 and 2020 to in excess of 100 million phones. Overall, it can be concluded that the socio-economic impacts on the different market players are of significance. These impacts should be carefully balanced with predicted environmental impacts which the evidence shows not to be significant. The proposed ban would severely limit the company's ability to continue in business, as well as imposing significant economic and social costs on its workers, customers and end-consumers and a burden on the environment in general.

2.2 *OUTLINE ENVIRONMENTAL ASSESSMENT*

In the environmental case, ERM analyses the implications of using the nano-coating upon the life cycle of the company's most popular product application – electronic devices. Firstly, this section compares the additional greenhouse gas emissions and climate change impact that the nano-coating process has upon the product's footprint. ERM finds this to be insignificant compared with those emissions associated with the production of the device. This is because of the small amount of C8F17-X monomer used in the coating process and the large number of units processed in each batch.

ERM has also explored the possible end-of-life management alternatives for treated electronic devices, in order to investigate the potential for the polymer coating to degrade into 8:2 FTOH, which would in turn have the potential to degrade into PFOA, or the impurity within the coating to enter the environment via that route. This is not believed to be significant, because electronic products will be subject to high levels of recovery at end-of-life, due to their status as WEEE, and because of the valuable materials that they contain. Recovery of these materials, via smelting of printed circuit boards and other components, will thermally decomposes the nano-coating and any PFOA. Finally, this section indicates those benefits associated with less waste, decreased return rates and longer product lifetimes.

3 SOCIO-ECONOMIC IMPACTS OF THE PROPOSED BAN ON THE COMPANY'S NANO-COATING TECHNOLOGY

3.1 MARKET OVERVIEW OF WATER AND OIL RESISTANT NANO-COATINGS

There are six main companies in the global vacuum-based nano-coatings marketplace and the market is relatively immature. To date, the companies are not known to have successfully established alternative fluorinated or non-fluorinated chemistry technology into the mainstream. It is also worth noting that multinational manufacturing company W. L. Gore & Associates, Inc. (W.L. Gore)– manufacturing outdoor clothing – has stated that it will not be able to meet its commitment to phase out the use of per- and polyfluorinated chemicals (PFCs). W.L. Gore previously stated that it would remove PFCs of environmental concern from 85% of its products by 2020, and from the remainder of its products by 2023. W.L. Gore highlight that the issue with meeting the 2020 deadline is due to technical challenges, specifically with implementing alternatives in some applications meaning that it has not yet fully achieved the commercial capability and scale to meet the 2020 goal. In this light, as emphasised throughout this report, this is the same issue that plasma nano-coating companies face – it requires enough time to successfully refine and adapt new technology to its applications.

All share a sealed vacuum chamber application process in order to coat materials and offer a similar technical effect, ranging from degrees of water-repellency through to electrically resistive coatings for products, achieved via the coating of a nano-thin polymer layer around devices and their inner components. There are no reliable data on the current size of the global market for nano-coatings, due to there being no published accounts in the public domain for these small and relatively new businesses.

Our client's company is well established in nano-coatings, defined by the number of electronic products treated annually to protect from water and corrosion damage. It has an established market with electronics companies, and, to a lesser extent, other product areas. Direct competitors using gas phase processing have not yet proven themselves at mass manufacturing levels, nor have they the capacity to deliver similar volumes. Although solution-based applications to electronic boards and components have been in the market for 40 years or more, they suffer from a lack of reliability and repeatability. Therefore, the company has a unique advantage in this market sector.

Uses of the company's water- and oil-repellent nano-coating currently fit into two main categories. The share of the company's revenue for each sector is as follows:

- Electronic products – 96.6%;
- Other – 3.4%;

As outlined below, in recent years consumer electronics have proved to represent the highest source of income to the market, whilst also offering major growth potential. Electronic devices represent 96.6% of the company's total market, rising by 12.6% from 84%, in the last three years (2015 to 2018). Consequently, this socio-economic assessment focuses on the effect of the proposed ban on this market.

The company provides innovative solutions to new markets that are very far from having realised their full potential. As a result, the company's growth potential is significant. A ban prior to 2023 on PFOA-related substances at the Global level would significantly hamper the company's business prospects, if not force it out of the market, as it would not have adequate time to address suitable alternatives.

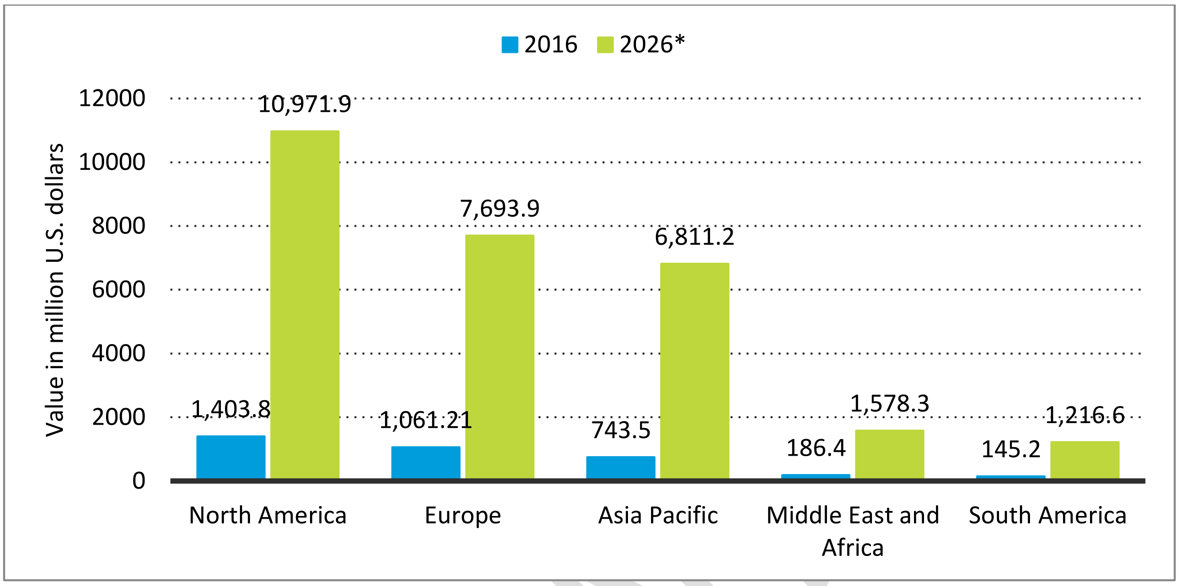
3.2 *MARKET GROWTH POTENTIAL FOR THE COMPANY COATING*

The nano-coatings technology sector has seen exceptionally rapid growth in the past three years (2015 to 2018), with the company's electronic devices sector rising by 12.6%. An example of this growth, and potential growth, is shown by the number of smart phones on the global market today is as follows:

2017	**2018**	**2019 (estimated)**	**2020 (estimated)**	**2021 (estimated)**	**2022 (estimated)**
1.45 billion	1.44 billion	1.46 billion	1.49 billion	1.52 billion	1.55 billion

Figure 3.1, below shows the market value of nano coatings worldwide in 2016 and projections for 2026, by region (in million U.S. dollars) (Global Nanocoatings Market - Analysis and Forecast (2017-2026), 2018):

Table 3.1. Market value of nanocoatings worldwide in 2016 and 2026, by region (in million U.S. dollars)



Currently, in 2019, on average worldwide, smartphones have a lifespan of 30.7 months, with the expected lifespan increasing year on year, to 32.4 months, by 2022 (Canalys, 2018). This lifespan is the shortest of electronic devices, due to a number of factors, notably including high damage and return rates.

Electronic device manufacturers, network carriers and end-consumers are expecting their products to become more reliable and robust as the technology matures. This objective increases the requirement for greater water- and oil-repellency of their products. Market research by 'Morning Consult' has shown that consumers value durability highly in their smartphone, emphasising the important of water and oil repellence for the company's products, and in turn, its end users. As the competition in the mid-market smartphone range increases drastically, the successful players will need to be cost-conscious and ensure high profitability. In turn, this will drive rationalisation of the product portfolios and an urgency to sell their products around the world. Increasing the reliability of the handsets to both water and corrosion damage has a significant return on investment which will both add value from the consumer side, and allow the manufacturer to become more competitive.

The company's annual sales are projected to grow by over 120% between 2018 and 2020. If the whole electronic products market mirrors the growth of smartphones, then the company anticipate that its solution will treat 100 million devices in 2020.

The company is likely to increase its employment and investment in research within Europe as the company grows, with new innovative applications for its technology.

3.3 *ALTERNATIVES*

Currently, despite screening alternative chemicals, the company does not have a *ready-for-use* alternative monomer with equivalent performance. It is important to consider that alternatives to C8F17-X related chemicals that may be suitable in other industries (particularly those where the chemicals are dissolved in a liquid, e.g. dip coating fabrics for outdoor clothing, floor polishes, paint wetting agents) may be not applicable to the plasma nano-coating business (which has the environmental benefit of not requiring a carrier liquid).

In order for a chemical to work in a plasma nano-coating process and give a liquid repellent polymer coating, it must meet three key criteria:

- Readily polymerisable;
- Volatile – more specifically, it needs to be volatile in a vacuum at 20 - 50°C; and
- Low surface energy.

The chemistries that the company has assessed as alternatives include short chain fluorinated chemistry, silicone based chemicals, Sulfosuccinates, Propylated aromatics and Alkyl acrylates: The alternatives and their properties are addressed below:

- **Perfluorobutanesulfonic acid (PFBS)** is not readily polymerisable, and is non-volatile;

- **6:2 fluorinated co-polymer monomers** meet all of the above-mentioned criteria, although the surface energy is lower (better) for the 8:2 version. The key issue between a switch from 8:2 to 6:2 is not so much the drop in technical performance, rather, the challenge of mass production to meet current throughput and costs. In-house work with 4:2 monomers has not yielded good results, and as the monomers become shorter and more volatile, the risk of flammability increases, meaning that special packaging is required for transportation. 6:2 alcohols and acids are not polymerisable, and thus, possess the disadvantage of being easier to disperse as single molecules if they do not chemically adhere to surfaces);

- **Silicone based chemicals** can give low surface energies, however, it can be challenging to find candidates that are suitable volatile and/or polymerisable;

- **Sulfosuccinates** and fatty alcohol polyglyocol ether sulfates are salts, and thus, are non-volatile;

- **Propylated aromatics** do not have polymerising groups, and have relatively high boiling points; and

- **Alkyl acrylates** are readily polymerisable and volatile, however, the surface energy would be inferior to that achieved by fluorocarbons. Many phones are already made with non-fluorinated plastics, however, unfortunately they let water in, therefore the liquid protection performance is not expected to sufficient.

In light of the above, the issue surrounding finding commercially available alternatives concerns comparable performance to the company's C8F17-X polymer. Alternative chemistries would affect the performance of the company's solution, with the main issue being the fundamental determinant of water- and oil-repellency. There is the chance that as a result of adopting shorter chain fluorocarbons, or other non-fluorinated alternatives, customer specifications would not be met, especially in products such as in-ear devices, which require high oil-repellence. This results in lower product attractiveness to customers and substitution to competitors' products – which, if they require water, solvents or volatile organics, has the potential to release more substances into the environment.

The key constraint of fluorinated alternatives is the fluorocarbon chain length, which determines water- and oil-repellency. In terms of the alternatives that have been researched, short chain fluorinated chemicals materials look likely to be a fit, however further research and development is required in order to address the challenge of mass production to meet current throughput and costs. This research is on-going at the company.

In relation to production and manufacturing, shorter chains will require a longer process time, and this will proportionally increase the carbon footprint of the process, so it's essential this is limited to the shortest time possible. It would be ideal to be able to continue to use the C8F17-X monomer in the nano-coating of consumer electronics and other products until this issue is addressed. Allowing a transitional period of up until 2023 should allow the company to address this appropriately as was approved under the EU REACH restriction.

Acceptable alternatives could require the synthesis of new precursors, in turn requiring R&D resources that the company does not currently possess. It would also require a significant length of time for it to be commercially available; time the company does not have if the worldwide ban comes into place before 2023.

As it is the fundamental chain length which confers water- and oil-repellency, developing an acceptable alternative will take significant time and resource. Given the competitive market in which the company operates and the reduced performance of an unsuitable alternative, it is unlikely that the company would be able to pass on additional R&D costs to its customers.

3.4 *SETTING OUT THE SCENARIOS*

The socio-economic impact assessment presented in this report assesses the costs a worldwide ban prior to 2023 would have on the different market players. In order to do so, it sets out scenarios to assess the effect of a potential ban in comparison to a business as usual situation. The following scenario is examined:

> A complete ban in force prior to 2023 on the manufacture, use or placing on the market of PFOA and PFOA-related substances on their own or as constituents of other substances.

3.5 *DIRECT ECONOMIC COST*

This sub-section assesses the direct economic costs of the proposed PFOA ban on the company's activities and the profitability of its business. The socio-economic impacts have focused on the company's largest market – electronic devices. The company's other markets have not been fully assessed and therefore the impacts are likely to be higher than the figures quoted.

It is likely that adoption of a complete ban of PFOA related substances prior to 2023 would affect the company in the following way.

- the company will not be allowed to process products in-house and will therefore have to stop all water protection nano-coating activities;
- Manufacturers will not be allowed to process products with the water protection at their sites and will therefore stop purchasing nano-coating chambers and monomer from the company; and
- Manufacturers and distributors will not be allowed to produce and supply C8F17-X nano-coated products to the global market and will therefore stop their purchases of the company's nano-coating chambers and C8F17-X monomer.

Overall, the company expects the above scenario to lead to complete cessation of all of its incomes and profits world-wide, if not granted enough time to address and implement a suitable alternative. The electronic device manufacturers continue to rationalize their product portfolios for cost advantages. To this end, if a product is not viable globally due to the company not being able to provide its technology, then it is highly unlikely that the client's technology will be adopted on that type or style of device in the future. A global ban prior to 2023 will lead to no adoption, and therefore impact 61% of the company's incomes and profits, if adequate time is not allowed to find a replacement chemistry.

The company's total turnover in 2018 was €13.6m ($15.4m), with similar or elevated projected annual sales between 2019 and 2023. [1].

Tables 3.2 & 3.3 show the total predicted effect on revenue of a ban in 2020. It is requested that the POPs Review Committee considers these in the context that the ban comes into a place at this date, where the company will not have had time to adequately address and implement alternatives.

Table 3.2

Model A - anticipating C8F17 time limited POPs exemption in line with EU REACH Annex XVII restriction, with nano-coating allowed until July 2023

Parameter (M EUR)		2018	2019	2020	2021	2022	2023	2024	Total 2019 -2023
Projected Company Revenue		13.6	21.5	47.9	62.9	81.4	95.5	108.5	309.2
Existing chemistry	Electronics	13.1	12.5	12.5	12.5	6.8	0	0	44.3
	Other	0.4	0.3	0.3	0.3	0.2	0	0	1.1
Alternative chemistry	Electronics	0	8.6	35	50	74.2	95.3	108.3	263.1
	Other	0	0.1	0.1	0.1	0.2	0.2	0.2	0.7

In Model A, above, during the years outlined red, this assumes business is reasonably flat, and anticipates a loss of business through the switch from C8 to alternative chemistry

Table 3.3

Model B - modelling Stockholm Convention Ban in July 2020, and Alt chem SP available by Q4 2019

Parameter (M EUR)		2018	2019	2020	2021	2022	2023	2024	Total 2019 -2023
Projected Company Revenue		13.6	21.5	41.1	57.9	79.0	95.5	108.5	295
Existing chemistry	Electronics	13.1	12.5	0	0	0	0	0	12.5
	Other	0.4	0.3	0	0	0	0	0	0.3
Alternative chemistry	Electronics	0	8.6	41	57.8	78.8	95.3	108.3	281.5
	Other	0	0.1	0.1	0.1	0.2	0.2	0.2	0.7

In Model B, above, it is observed that a more sudden ban, for example in 2019, may cause customers to look at alternative technologies themselves, and reduce the uptake of the more environmentally friendly alternative chemistry

[1] Exchange rate of 1 EUR equal 1..13 USD source: www.xe.com on 7 March 2019

coatings that the company is to offer. During the years outlined in red (2019-2023), the estimated is a loss of revenue of >14 million. This would cause enough cash flow issues to prevent bringing more environmentally friendly solutions to market.

The company has benefited from significant shareholder capital investment since it was established. Presently, total investments represent more than €63m, both in tangible and intangible assets. Investments have been made in a business-as-usual mind-set, as the risks of the proposed ban were not material at the time of the early investments. Direct economic costs incurred by the company following a complete ban before they have had time to address a suitable alternative, would be likely to reduce drastically their financial health and the value of its shares, potentially causing the business to cease or be restructured in a dramatically reduced form.

3.6 EMPLOYMENT COSTS

The company employs 137 people globally. In Europe, they employ 90 workers and administrative staff, and 47 in the rest of the world. Where the company's growth prospects are good, it is likely that there will be a net increase of 5% in employment in the short to medium term. For 11/12 months of 2018, employment costs were £7,596,191, which can be projected to annual employment cost of £8,286,753.

A complete ban of PFOA related substances without any ready-for-use alternative will lead to an immediate drop of 60% of their revenue in the short to medium term. This will be likely to lead to the company's strategic repositioning of activities from production to R&D, resulting in a net loss of employment in the short term. A conservative estimate was made that 50% of their employees would lose their jobs (in fact, the proportion of workers losing their jobs in this scenario would be much higher). This is based on the projection that there would be a 7 million drop in revenue (projected for 2020), if PFOA related substances were banned worldwide prior to 2023. This would hinder the medium term goals of introducing more environmentally friendly alternative chemistries. The company requires an adequate amount of time for customers to adjust expectations in light of regulatory changes and the company to implement alternatives.

Table 3.4 Company employment impact of a complete ban

	Units	**the company – Scenario A**
Number of Full Time Equivalent employees	Number	137
Estimated number of employees that would lose their jobs	Number	68.6
Average annual net earnings in Europe	€/year	41,267
Average European long term unemployment rate	%	1.7%
NPV of loss of annual earnings due to long term unemployment (2019 to 2023) year time horizon)	€	240,627

3.7 INDIRECT IMPACTS ALONG THE SUPPLY CHAIN

3.7.1 *Downstream impacts*

It is expected that:

- Manufacturers who are users of the company's licensed nano-coating technology will not be allowed to process products at their sites with the existing monomer;
- Manufacturers users of the company's licensed nano-coating technology will not be allowed to supply C8F17-X nano-coated products to the European market (despite the current EU extension to 2023);
- Distributors will not be allowed to supply the company's nano-coated products on the market; and
- World-wide customers will not adopt the technology as they will be unable to distribute treated product.

As mentioned previously, in the short term there are no ready-for-use alternatives. The company's customers would see a decrease in water- and oil-protection offered to their products, which would mean products with lower performance.

Without adequate time to implement a suitable alternative, specific products would have to be withdrawn due to this significant lowering of performance. Customers would lose market share to competitors as their products are not as attractive or do not fulfil their intended function. The equipment used by all customers and the company treating products would also require decontamination and possible replacement. This is due to the possibility that residual C8 fragments could contaminate products with PFOA and related substances. ERM has not attempted to monetise this impact, but it should be considered significant because of the cost of replacement hardware, including installation and set-up is in the region of €135,000 per unit (and the company currently have over 200 systems in total). The company's business continues and more machine sales and deployments are ongoing.

One metric for evaluating the success of an electronic product is its return rate. Taking smartphones as an example, a SquareTrade Research Brief (2010) [1] analysed failure rates of over 50,000 smart phones covered by SquareTrade Care Plans showed that water damage is the second main cause of accidental damage and caused 5% of all phone failures within their first year of ownership. This is a conservative figure, as other information sources

[1] Source: https://www.squaretrade.com/cell-phone-comparison-study-nov-10

estimate that 30% of phones are exposed to liquid challenges, which is highlighted in the *Data and limitations* section of this report.

In addition, data provided by a company's customer shows a 38% reduction in water damage of their electronic devices when processed with the company's coating. If this was extrapolated to smartphones, then this would mean that altogether the company's coating could reduce annual phone failures by 2%. With over 44 million electronic devices coated by the company's technology in 2018, in the case of a complete ban, manufacturers and insurers would experience increased costs due to higher return rates of products as a result of water damage.

The company's projections are that 90 million electronic devices will be processed in 2019 and 100 million in 2020. However, the exact cost of increased return rates cannot be assessed, as precise water damage return rates are unknown to the company across all of its customers' product portfolios.

If the worldwide ban were to come into place prior to 2023, additional costs would also be incurred by manufacturers and suppliers not being able to distribute those electronic devices that have already been nano-coated and are in stock. Significant litigation costs may be incurred by manufacturers and the company, as its customers look to recover their costs relating to nano-coated products.

3.7.2 Impacts on the end consumer

Without the implementation of a suitable alternative, end-consumers will see an inferior product with significantly lower water- and oil-repellency performance as a result of losing the nano-coating. This will increase the probability of product failure and replacement costs. The current additional costs to manufacturing, which are in the region of €1.36 per unit, significantly outweigh the replacement costs of sophisticated electronic products with investment in the company's solutions presenting an attractive return on investment.

Table 3.7 NPV of replacement costs impacts to end consumers

	2018	2019	2020	2021	2022	2023	2024	Total 2019 to 2023
Number of coated electronic devices - m (projections)	44.0	90.0	100.0	110.0	120.0	130.0	140.0	
Devices saved from water damage by the coating technology - Global (m)	0.3	0.7	0.8	0.8	0.9	1.0	1.1	
Total value of devices saved - Global (€m)	76.2	156.0	173.3	190.6	207.9	225.3	242.6	642.5

3.8 *SOCIO ECONOMIC ANALYSIS SUMMARY*

In this study, ERM analysed the commercial and social potential of the company's solution, as the technology employed is novel and the benefits of innovation are still to be fully realised. Its growth prospects within existing markets are high, as its solutions could be used in wider product ranges and further applications in the future. The proposed ban would significantly hamper the company's prospects of remaining a global leader in this market.

The assessment describes the likely impacts of a complete ban on PFOA-related substances prior to 2023, in terms of direct economic costs to the company, social costs to its employees and indirect upstream and downstream costs along the supply chain up to the end-consumer.

ERM's assessment shows that a global ban of the C8F17-X monomer as a PFOA-related substance, prior to 2023, would have a significant economic effect. Impacts have been monetised where possible, depending on data availability and using conservative estimates. The costs that have been possible to monetise are:

- direct cost to the company in terms of loss of revenue and gross profit;
- employment costs in terms of loss of employment and annual earnings;
- upstream cost for suppliers from the company reduced expenditures in a selection of consumables; and
- end consumer costs from smartphones replacement rate.

The results show that, globally, the socio-economic impacts of a complete ban on PFOA-related substances and a subsequent decrease in the company's activities would be likely to lead to a minimum total cost over 5 years (2019 to 2023) year period of **€0.95** billion NPV, most of which comes from increased consumer costs.

Likely significant costs that were not possible to monetise are:

- Litigation costs incurred by manufacturers and the company as customers look to recover costs relating to nano-coated products and processing equipment;
- Indirect upstream impacts, reduction in overall upstream expenditures, and reduced consumption due to loss of employment and end-consumer replacement costs;
- Downstream costs on manufacturers and distributors from lower product performances and higher return rates of electronic devices; and

- End consumer costs from 'smart' electronic devices requiring replacement from water damage.

Overall, the assessment demonstrates that socio-economic impacts on the different market players are significant. These impacts should be carefully balanced with the limited benefits that reduced health and environmental impacts as a result of constraints on the company activities through the proposed ban on PFOA and PFOA-related substances would have on workers, its consumers and the environment in general. A qualitative cost benefit analysis of the proposed ban is displayed in Table 3.7.

Table 3.7 Qualitative cost and benefit analysis of proposed PFOA ban

Socio-economic impacts	Environmental impacts
Direct economic cost: highly significant (€295m NPV between 2019-2023)	Environmental benefits (the company coating's environmental impact: not significant)
Employment cost: significant (€0.24m NPV between 2019-2023)	Increased waste from electronic device replacement (moderately significant)
Upstream impacts: highly significant (€15m NPV between 2019-2023)	Increased environmental impacts from higher production of electronic devices (moderately significant)
Indirect upstream impacts: likely significant (not monetised)	
Downstream impacts: significant (not monetised)	
End consumer cost: very significant (€642m NPV between 2019-2023 - smartphones only)	
ERM considers that socio-economic costs largely outweigh uncertain environmental benefits	

The company nano-coating uses very small quantities of C8F17-X monomer when polymerised. The amount deposited on an average device is approximately 3mg, which provides significant benefits with respect to water repellence and corrosion damage protection compared to an uncoated product.

As the list of products that have the company coating is extensive, let's consider the application to smartphones as there is plenty of data available about them. Supplementary information for other products is provided where customers have provided a response.

4.1 IMPACT OF ADDITIONAL NANO-COATING TO PRODUCT

The data presented in *Table 4.1* show that the potential environmental impact per unit of coated product is considerably outweighed by the performance benefits discussed in the following section in terms of decreased water damage, oil repellence and corrosion.

Table 4.1 Energy and material usage for the company coating

Input	Unit	Value	Climate change impact (kg CO_2e)
Electricity consumption of plasma coating chamber	kWh per item	[figures will be provided in addendum to response once primary data collected] [1]	
Monomer consumption	mg per item	3	0.29 [2]

When the company-coated electronic devices are managed at end-of-life, it will be in accordance with the WEEE Directive within the Member States. Consequently, they will be re-conditioned, if there is a high resale, or recycled and the materials recovered where possible.

In relation to the EU, the EU Commission has defined a list of critical raw materials [3], in which the recovery from recycled high-value electronic products would be an important supply stream. In a single smartphone, there are typically quantities of precious metals significantly greater than the mass

[1] Using an emission factor of 0.53748 $kgCO_2e$/ KWh for UK Electricity including transmission & distribution from DEFRA/ DECC UK Government conversion factors for Company Reporting 2014

[2] Using a proxy emission factor of 96.5 $kgCO_2e$/kg for perfluropentane from Ecoinvent 3.0

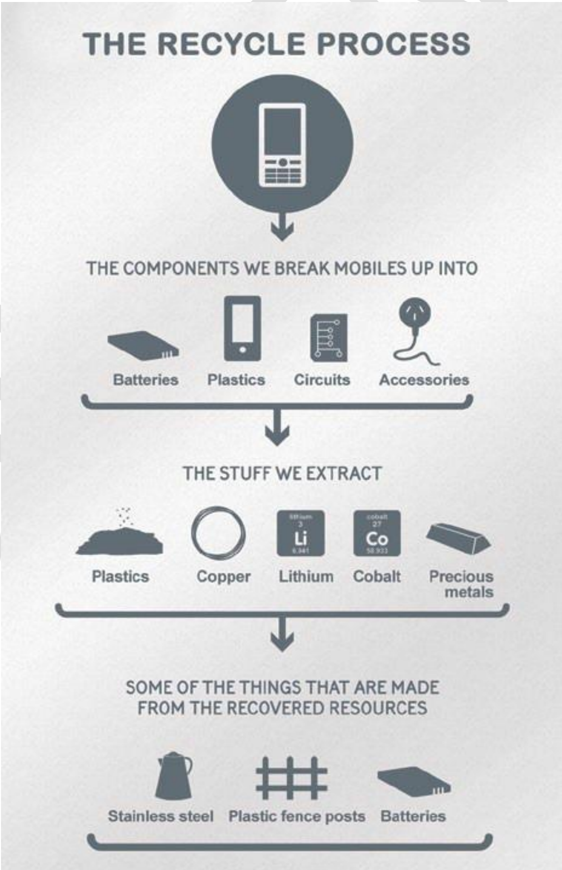
[3] https://ec.europa.eu/growth/sectors/raw-materials/specific-interest/critical_en

of the company's coating, with approximately 34mg of gold and 340mg of silver, compared to 3mg of coating [1].

Electronic devices, a large current and target market for the company, would normally be processed in a similar way to *Figure 4.1*, below. The device is disassembled into its main constituent parts and then the precious metals are recovered primarily through thermal processes such as smelting. This would thermally decompose the company nano-coating and avoid the release of PFOA into the environment.

The plastics components of the device are likely to be reused in a closed loop process or incinerated with energy recovery. The latter route would also mean that any the company coating would thermally decompose, whilst with the former, levels of PFOA related to the company coating would be difficult to detect or quantify due to the small quantities involved. The US EPA has investigated the potential for the incineration of waste fluorotelomer-based polymers to be a source of PFOA. Taylor *et al*. (2014) found no PFOA at detectable levels.

Figure 4.1 Mobile phone recycling process



Source: http://www.mobilemuster.com.au/learn-about-recycling/

[1] http://www.electronicproducts.com/Computer_Systems/Standalone_Mobile/How_much_precious_metal_is_in_your_iPhone.aspx

The extremely small amounts of the company coating and the respective PFOA impurity would not cause a significant impact to the environment from the end of life recycling and recovery of materials.

However, if any products coated using the company's solution are disposed to landfill, there is a possibility for the polymer to degrade to 8:2 FTOH and eventually to release PFOA. Buck *et al*. (2011) states that the potential half-life could be in excess of 1000 years and consequently would the yield of PFOA exhibited would be sufficiently low that their contribution to the environmental inventory is likely to be insignificant.

Moreover, the US EPA has recently published a degradability study [1] of commercial acrylate-linked fluorotelomer-based polymers, which estimates half-lives of between 33 and 112 years, showing the potential for a quicker release of fluorotelomer and perfluorinated compounds to the environment. The potential amounts of PFOA that could be released to the environment by the company's nano-coated products are extremely small, due to the quantity employed being milligrams per unit, with nanograms of PFOA present as an impurity, as mentioned above.

The total amount of PFOA generated from the use of 2200kg of C8F17-X monomer in 2014, resulting in the coating of 33 million devices, as well as numerous other products, is in the region of 88g. When compared to the emissions and PFOA product content reported by the eight companies who are part of the US EPA's product stewardship programme, as seen in *Table 4.2*, this quantity is seen to be insignificant. As the quantity of PFOA generated is currently negligible, and therefore so is the environmental impact, the company feels that is reasonable to allow its continued use of the C8F17-X monomer up until 2023, until it is able to implement a suitable alternative.

Table 4.2 US EPA Reported Emissions and Product Content of PFOA, PFOA Salts and Higher Homologues from US & Non-U.S. Operations in 2013

Company	**PFOA, PFOA salts & higher homologues releases to all media from fluoropolymer and telomer manufacturing (kg)**
Arkema	>1000 – 4000
Asahi	20.1
BASF (Ciba)	n/a
Clariant	1.0
Daikin	not reported
DuPont	135
Dyneon/ 3M	0
Solvay Solexis	n/a

Source: http://www.epa.gov/oppt/pfoa/pubs/stewardship/preports8.html

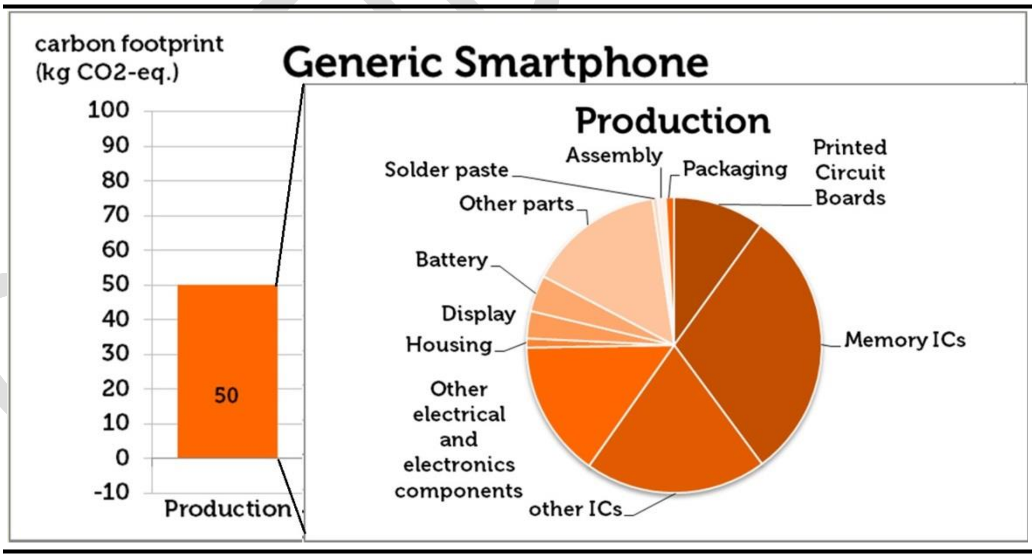
[1] http://pubs.acs.org/doi/abs/10.1021/es504347u

4.2 IMPLICATIONS ON THE LIFE CYCLE OF PRODUCTS WITH THE COMPANY COATING

Electronic devices have a significant environmental impact, which is mainly associated with the manufacture of printed circuit boards, memory and processing chips, as well as other electrical components [1]. A carbon footprint is one measure of assessing the environmental impact of a product and its potential contribution to climate change. *Figure 4.2* shows the contribution from a device's constituent components. All of the most significant components are at risk from water damage and corrosion, which would result in the malfunction of the device and a shortening of the product lifespan.

As consumer electronic devices become more embedded and ubiquitous in society there is a growing trend in the industry for IPx7 level performance. This requires that an electrical device is still able to function when being submerged under one metre depth of water for a minimum of 30 minutes [2]. The company's coating provides this level of performance without the need for manufactures to design and use components such as rubber O-rings, membranes and gaskets. At the end of the device's life cycle, these components do not have a high value – containing no precious metals and would have to go to landfill or municipal waste incineration. The company's coating does not require all these additional components to be either manufactured or disposed, which reduces the environmental impact associated with the production of the electronic device.

Figure 4.2 ***Cradle-to-gave carbon footprint of generic smartphone***



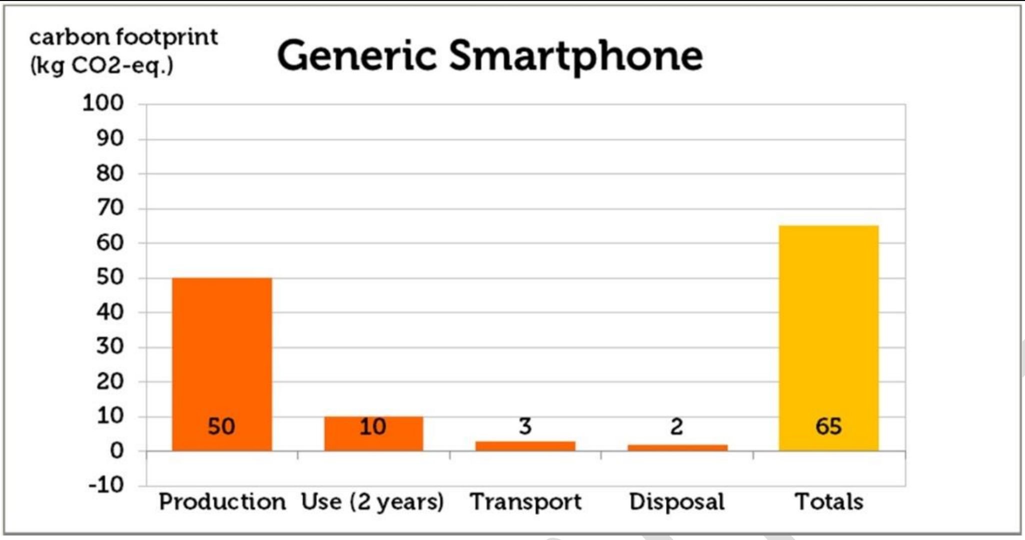
Source: http://www.fairphone.com/wp-content/uploads/2013/08/2.jpg

[1] http://www.fairphone.com/2013/08/01/whats-in-a-life-cycle-assessment/

[2] http://www.nema.org/Standards/ComplimentaryDocuments/ANSI-IEC-60529.pdf

For a smartphone, its production is also the main contributor to its overall cradle-to-grave carbon footprint, amounting to 50kg CO_2e, which is approximately 77% of the whole footprint, as seen in *Figure 4.3*.

Figure 4.3 ***Cradle-to-grave carbon footprint of generic smartphone***



Source: http://www.fairphone.com/wp-content/uploads/2013/08/1.jpg

4.3 DECREASED WATER DAMAGE RATES

There are significant ongoing environmental benefits related to the company's nano-coating of electronic devices. With smartphones as an example, water damage is a major contributor to the accidental damage and subsequent malfunction, with a 2016 study stating the proportion of smartphone repairs due to water damage to be 35.1%, with 4.5% of smartphones being shipped,, worldwide, due to this type of damage [1]. With the number growing as smartphone sales increase year on year, this is an increasing problem. An electronic device coated with the company's nano-coating has been found by suppliers to reduce the return rates as a result of water damage by 38%. The removal of the company's technology from devices would likely see an increase in water related damage, requiring increased use of resources in order to repair, or, if the prodcut is damaged beyond repair – increased use of resources in order to recycle. It is also worth noting that in the case of phones that that are beyond repair, recycling is not always observed; therefore in this case, an increased amount of smartphones would end up in landfill.

The potential environmental benefits associated with the 44 million devices treated by the company in 2018 alone, as a result of avoided water damage failure were:

- over 800 thousand damaged devices prevented from being returned to the manufacturer, with subsequent end of life management obligations;

- over 42,000 tonnes of CO_2e production emissions associated with replacement products avoided, which is equivalent to the annual emissions of 9,000 cars; and
- an estimated reduction of over 6600 tonnes of high-value hazardous electronic waste.

If all 1.44 billion devices shipped worldwide in 2018 contained the company nano-coating in the future, the estimated annual waste and carbons savings would equate to:

- over 27 million products prevented from being returned annually to the manufacturers with consequent end of life management obligations;
- more than 1.4 million tonnes of CO_2 saved each year through reduced production emissions, equivalent to the annual energy consumption of more than 120,000 households [1]

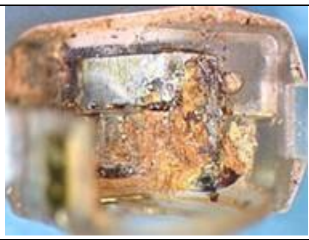
Allowing the continued global use of the C8F17-X monomer until 2023, would allow the above-mentioned environmental benefits to continue up until that date in terms of the continued use of said monomer, and beyond 2023, in terms of the replacement substance being a suitable alternative when implemented. the company aims to replace the C8F17-X monomer with an alternative that offers the same environmental benefits as C8F17-X.

In 2014, United Nations University estimated that roughly 42 million tons of e-waste was generated, three million of which were generated from small IT, such as smartphones (Greenpeace, 2017). Again, in the same vein as that described above, allowing the company to manufacture its products with the C8F17-X monomer until 2023, would ensure products continue to possess water and oil resistant technologies, therefore reducing e-waste, and the negative impact of e-waste on the environment.

Another the company customer, which puts its products through a high humidity test, has provided *Figure 4.4*, showing the difference in corrosion inside the battery door of a body worn device. Its products are better protected against ingression of sweat, which prevents corrosion of in-ear products as well as preventing blockages of microphones and speaker openings with ear wax and other oily substances. Short chain fluorinated chemistry may be able to provide the same level of oil repellency, however, time is needed to find the best chemistry, and in order to refine the processes to implement the technology.

[1] http://www.epa.gov/cleanenergy/energy-resources/calculator.html#results

Figure 4.4 ***Comparison between an uncoated and the company's nano-coated component***

Uncoated	Nano-Coated
	

4.4 *IMPACTS ON THE ENVIRONMENT FROM SUBSTITUTION WITH SHORT CHAIN FLUORINATED ALTERNATIVES*

It has been widely acknowledged that C4 or C6 fluorinated alternatives do not have the same performance characteristics as C8F17-X polymers (Honda *et al*, 2005). The Restriction Report (ECHA 2014) also states that this is the case. Short chain alternatives would need significant additional R&D, new processing equipment, possible chemical precursors and could not achieve the same performance characteristics due to the fundamental difference in chain length. It is felt that replacement with poorer alternatives would incur additional environmental impacts associated with capital expenditures that would not be incurred with the continued use of the C8F17-X monomer, up until 2023, and subsequently, replacement with an appropriate alternative and process.

Lower-performing short chain fluorinated alternatives would also have a negative impact on the reduction in water-damage wastage rates. Consequently, there would be a reduction in the benefits currently being achieved as a result of less electronic waste and less material consumption. There would also be an increased environmental impact from additional raw materials required for the production of replacement smartphones.

Many short chain alternatives employ a wet technology that requires a product to be sprayed or dipped in order for a coating to be provided. The company's low pressure vacuum process has two distinct environmental advantages over wet technologies. Workers using the wet technology would have a higher occupational exposure to fluorocarbons from an increased risk of volatile organic compounds being released into the environment, whereas the the company process is in a sealed vacuum. Secondly, the nano-coating process uses significantly fewer raw materials in the form of the C8F17-X monomer use and polymer deposited compared to a wet technology. This would also have a much higher amounts of wastage associated with surplus liquid after the batch run or residues once the product is coated.

5 DATA AND LIMITATIONS

Much of the data presented in this report is a repetition of data prepared in response to the EU REACH restriction consultation updated with current day figures and extrapolated to the global scale where applicable. It has not been possible to account for a wider range of scenarios, data variability and associated sensitivity analyses. If a full socio-economic assessment were to be carried out, ERM would expect to examine, *inter alia*:

- the implications of using a 25 year horizon;
- further socio-economic impact scenarios on how the proposed ban would affect the company;
- the implications of an alternative source of information for the water damage rate of smartphones, which states that 30% of phones face liquid challenges;
- the effect of achieving a greater than 38% reduction in return rate;
- the chemical risks associated with end-of-life exposure scenarios;
- the chemical risks associated with the company's occupational exposure scenario;
- further investigation into the potential degradation of the C8F17-X polymer to PFOA; and
- the energy consumption of the company's nano-coating process.

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7 ACRONYMS

ECHA	European Chemicals Agency
EU	European Union
PBT	Persistent, bioaccumulative and toxic
PFOA	Perfluorooctanoic acid
Ppb	Parts per billion
SVHC	Substance of very high concern
US EPA	US Environmental Protection Agency

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