PlasticsEurope Fluoropolymer Products Group (FPG)

Socioeconomic Impact Assessment for fluoropolymers

FPG response to the PFAS draft restriction proposal

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CONTENTS

List of Tables

List of Figures

Acronyms and Abbreviations

Name	Description
AEMEL	Anionic exchange membrane electrolysers
API	Active pharmaceutical ingredient
CfE	Call for Evidence
CSS	Chemicals Strategy for Sustainability
ECHA	European Chemicals Agency
ECTFE	Ethylene chlorotrifluoroethylene
EEA	European Economic Area (EU plus Norway, Iceland and Liechtenstein)
EPDM	Ethylene propylene diene terpolymer
ETFE	Ethylene tetrafluoroethylene
EV	Electric vehicles
e-VTOL	Electrical vertical take-off and landing
FCM	Food contact materials
FDA	Food and Drug Administration
FEPM	1-Propene, polymer with 1,1,2,2-tetrafluoroethene
FEVE	Fluoroethylene vinyl ether
FEP	Fluorinated ethylene propylene
FFF	Fire-fighting foams
FFKM	Copolymer of tetrafluoroethylene and perfluoromethylvinylether
FP	Fluoropolymers
FPG	Fluoropolymers Product Group of PlasticsEurope
GDL	Gas diffusion layer
HEPA	High-efficiency particulate air
HNBR	Hydrogenated nitrile butadiene rubber
IVD	*In vitro* diagnostics
LNG	Liquefied natural gas
MDD	Medical Devices Directive 76/764/EEC
MDI	Metered dose inhalers
MDR	Medical Devices Regulation (EU) 2017/745
MEA	Membrane electrode assemblies
NBR	Nitrile butadiene rubber
NPV	Net Present Value
OEM	Original Equipment Manufacturer
OPC	Open Public Consultation
PA	Polyamide
PAVE	Perfluoroalkyl vinyl ether
PCTFE	Polychlorotrifluoroethylene
PEEK	Polyether ether ketone
PEMEL	Proton exchange membrane electrolysers
PEMFC	Proton exchange membrane fuel cells
PET	Polyethylene terephthalate
PFA	Perfluoroalkoxy polymer
PFAS	Per- and polyfluoroalkyl substances
PFCA	Perfluorocarboxylic acids

Name	Description
PFHxA	Undecafluorohexanoic acid
PFHxS	Perfluorohexane-1-sulphonic acid
PFOA	Perfluorooctanoic acid
PFPE	Perfluoropolyether
PP	Polypropylene
PPAP	Production part approval process
PPE	Personal protective equipment
PTFE	Polytetrafluoroethylene
PVC	Polyvinylchloride
PVDF	Polyvinylidene fluoride
SEA	Socioeconomic analysis
SOP	Start of production
TULAC	Textiles, upholstery, leather, apparel and carpets
VOC	Volatile organic compounds
XLPE	Cross-linked polyethylene

1. EXECUTIVE SUMMARY

- Value of fluoropolymers sold in the EEA in 2022 was €1.0 – 3.0 billion – expected to be €1.2 – 3.5 billion in 2025.
- Value of downstream markets using fluoropolymers was more than €700 billion in 2022 – can be more than €1 trillion in 2025.
- Proposed and considered derogations only cover an estimated 13-17% of fluoropolymer use in the EEA.
- NPV of loss for EU fluoropolymer industry in case of limited derogation for 2025-2030 period can be in the range of €6.2 – 18 billion.
- NPV of relevant downstream markets for the same period can be as high as €4.8 – 7.2 trillion.
- Fluoropolymers are key for all major industry sectors in the EEA, enabling key products and technologies for the functioning of the EEA society and economy and contributing to the EEA's climate change ambitions.

PlasticsEurope's fluoropolymer group (FPG) has prepared this report as part of their response to the open public consultation (OPC) for the PFAS restriction proposal. The aim of the report is to provide information on the socioeconomic benefits of the continued use of fluoropolymers in their applications across a broad range of industry sectors in the EEA.

The value of the fluoropolymers sold in the EEA in 2022 was estimated via an FPG member survey to be in the range of € 1.0 – 3.0 billion, and this number is expected to increase at a modest rate to approximately € 1.2 – 3.5 billion in 2025. Manufacturing in the EEA may decline, also following decisions from some manufacturers to stop production in the near future, but the overall demand is not expected to diminish, considering the importance of fluoropolymers for some major downstream industry sectors, including transportation (including electric vehicles), semiconductors and energy (including hydrogen and batteries).

The PFAS restriction proposal includes a large list of targeted, time-limited derogations for specific uses of PFAS and fluoropolymers. However, despite the number of applications and sectors considered for derogations, the vast majority of fluoropolymer uses are not covered by a proposed derogation, despite them being essential for many downstream manufacturing processes and products. For example, no derogation is envisaged at present in the restriction proposal for applications of fluoropolymers in the chemicals industry, in construction, and in potable water and wastewater treatment, while the proposed derogations for transport and energy applications would cover only a small share of the essential fluoropolymer applications. Overall, this report estimates that more than 80% of the fluoropolymer quantities sold in the EEA would not be covered by a currently proposed derogation and would potentially have to stop after the 18-month transitional period envisaged in the restriction proposal. This would mean that fluoropolymer manufacturing operations in the EEA will stop completely, as the volume covered by the proposed derogations would be too small to justify continued production, and the fluoropolymer production lines cannot easily be repurposed for different products. This could result in an overall loss of EU revenue in the range of € 6.2 – 18 billion for the 2025 – 2030 period, discounted to 2025 prices[1], along with the highly specialised and high value assets.

In case of a limited derogation scenario, in which the proposed derogations in the PFAS restriction proposal will remain as they are, the largest impact is expected to be felt by the downstream users that rely on the use of fluoropolymers for their processes and products. This report estimates that a market value of between € 700 and €1,400 billion in 2021 relied on the use of fluoropolymers in the EEA. In most, if not all, of these uses, fluoropolymers are necessary to achieve the desired product performance or process safety and reliability. It must be noted that the restriction would also prohibit imports of fluoropolymers for use in manufacturing processes, as well as in articles and equipment, such as vehicles, electronic equipment and medical devices.

[1] This assumes the EiF of the restriction in 2025.

It should be noted that the values presented above were calculated based on a number of assumptions and, in some cases, limited data, so can be considered as an indication of the size of the EU economy connected to the use of fluoropolymers rather than representing potential economic impacts in case fluoropolymers are subject to the derogation in the PFAS restriction proposal.

In any case, the benefits to the EEA society enabled by the use of fluoropolymers are manifold. Advanced technologies and products in medical devices, transportation, semiconductors and energy and electrical and electronic devices would not be possible without fluoropolymer components and coatings. In addition, critical (petro)chemical, pharmaceutical and other manufacturing processes can be operated safely and reliably thanks to fluoropolymer equipment, such as sealings, pipe linings, and filtering / separation membranes.

Fluoropolymers also enable the development of technologies that contribute to the EU's decarbonisation goals and circular economy, and the EU Green Deal. Technologies such as electric vehicles, smart electricity grids and hydrogen fuel cells would be pushed several years back if use of fluoropolymers is banned in the EU.

Overall, a scope-limited derogation scenario could result in significant impacts not just for the fluoropolymer manufacturers, but for the whole EEA economy and society. These critical functions of fluoropolymers should therefore be taken into consideration with an extended derogation for fluoropolymers.

2. BACKGROUND INFORMATION

2.1 Regulatory background on PFAS and fluoropolymers

On 14 October 2020, as part of the EU's zero pollution and circular economy ambitions (which in turn are key commitments of the European Green Deal), the European Commission published its Chemicals Strategy for Sustainability (CSS). The strategy contains several 'key actions', one of which is to phase out per- and polyfluoroalkyl substances (PFAS) in the EU, unless their use is proven essential to society[2].

More specifically, with regard to PFAS, the strategy highlights the following:

> "Per- and polyfluoroalkyl substances (PFAS) require special attention, considering the large number of cases of contamination of soil and water - including drinking water - in the EU and globally, the number of people affected with a full spectrum of illnesses and the related societal and economic costs. That is why the Commission proposes a comprehensive set of actions to address the use of and contamination with PFAS. Those aim to ensure, in particular, that the use of PFAS is phased out in the EU, unless it is proven essential for society.
>
> The Commission will:
>
> - Ban all PFAS as a group in fire-fighting foams as well as in other uses, allowing their use only where they are essential for society;
> - Address PFAS with a group approach, under relevant legislation on water, sustainable products, food, industrial emissions, and waste;
> - Address PFAS concerns on a global scale through the relevant international fora and in bilateral policy dialogues with third countries;
> - Establish an EU-wide approach and provide financial support under research and innovation programmes to identify and develop innovative methodologies for remediating PFAS contamination in the environment and in products;
> - Provide research and innovation funding for safe innovations to substitute PFAS under Horizon Europe".[3]

A Commission Staff Working Document[4] on PFAS accompanied the CSS. This further detailed the possibility for future regulatory initiatives concerning PFAS to address them as a group, primarily due to the prevalence of regrettable substitution as seen in the case of long-chain PFAS[5].

Meanwhile, the EU has been actively working to restrict the manufacture, use and placing on the market of PFAS in the European Economic Area (EEA).

- Entry 68 of Annex XVII of REACH (Restriction List) restricts the manufacture, use and placing on the market of C9-C14 perfluorocarboxylic acids (PFCAs), including their salts and any combinations thereof above a certain concentration in the mixture or article. The restriction includes derogations until July 2025

[2] Note: there is as yet no formal definition from the Commission as to what constitutes Essential Use.

[3] European Commission (2020a): Chemicals Strategy for Sustainability Towards a Toxic-Free Environment. Available at https://ec.europa.eu/environment/pdf/chemicals/2020/10/Strategy.pdf (accessed 31 October 2022).

[4] European Commission (2020b): Commission Staff Working Document on Poly- and perfluoroalkyl substances (PFAS). Available at https://op.europa.eu/en/publication-detail/-/publication/2614f1f2-0f02-11eb-bc07-01aa75ed71a1/language-en (accessed 31 October 2022).

[5] As noted within the RfP "*the EU has been regulating certain PFASs under the EU REACH Regulation as well as proposing regulation of the group of substances under the UN Stockholm Convention (Persistent Organic Pollutants). The most notable regulatory activity was to get PFOA, its salts and related substances ('C8 chemistry') under the EU REACH Restriction scheme. The industry moved on from 'C8 chemistry' to alternatives such as the so-called short-chain chemistry, incl. perfluorohexanoic acid (PFHxA), its salts and related substances ('C6 chemistry'). A REACH Restriction proposal for PFHxA and C9-C14 substances was submitted in late December 2019. ECHA's opinion was finalized in mid-2022.*"

for uses in semi-conductor manufacturing, photographic coatings in films, invasive and implantable medical devices and in some fire-fighting foams[6]. This restriction originally also included perfluorooctanoic acid (PFOA), its salts and PFOA-related substances, but the scope was narrowed down to C9-C14 acids after the inclusion of PFOA in Annex I (prohibition) of the POP Regulation in 2020.

- Perfluorohexane-1-sulphonic acid (PFHxS), its salts and related substances was also included in Annex IV (waste management provisions) of the POP Regulation in 2022.
- Undecafluorohexanoic acid (PFHxA), its salts and related substances are in the process of being restricted in the EU. The draft implementing act by the European Commission has a more limited scope than the original proposal, suggested specific restrictions, rather than a broad restriction with specific derogations[7].
- PFAS in fire-fighting foams (FFF).

It must be noted that the restriction initiatives listed above are all very specific, in that they define a narrow scope, either by listing specific substances of known risk (PFCAs, PFHxA) or a well-defined application (FFF).

Nevertheless, at the time of publication of the CSS, the REACH competent authorities for Denmark, Germany, the Netherlands, Norway and Sweden had already initiated preliminary work on the (now published) broad (universal) restriction, covering all uses of a group of around 10,000 PFAS:

- A regulatory management option analysis conclusion document was published by the aforementioned authorities in June 2021[8]. The document concluded that "*a broad restriction under REACH covering all PFAS as a group would be the preferred option in order to limit as many (non-essential) uses as practically possible. This would have the greatest impact on minimising human and environmental exposure to PFAS, would also include currently unknown PFAS and uses, and would prevent regrettable substitution of restricted PFAS by other PFAS";*
- The registry of restriction intentions until outcome was subsequently updated on 15 July 2021, with a scope for a "*restriction on manufacture, placing on the market and use of PFAS*"[9];
- A consultation was held between 19 July 2021 and 17 October 2021[10] whereby the authorities also presented multiple summary reports associated with EEA-based uses, tonnages and emissions. The purpose of the consultation was for stakeholders to check the presented data and provide feedback to support that the correct information is used for the assessment and preparation of the REACH Annex XV Restriction Dossier;
- Upon the submission of a formal restriction intention, the responsible competent authority has 12 months to submit its dossier to ECHA. However, the relevant authorities announced (in February 2022) a 6-month delay in submission, with an updated expected date of submission to ECHA of 13 January 2023; and
- On February 7, 2023, ECHA pre-published the full restriction report for the EU REACH restriction proposal, which aims to ban the uses of more than 10,000 PFAS.
- On March 22, 2023, ECHA formally published the Annex XV report for the EU REACH restriction proposal and kicked off the six-month open public consultation (closing on 25 September 2023), giving all stakeholders the opportunity to submit information on their PFAS uses and the availability of alternatives.

The universal PFAS restriction proposal focuses on the manufacture, placing on the market and use of PFAS, including polymeric PFAS (fluoropolymers). The restriction proposal defines PFAS as "*Any substance that*

[6] See https://echa.europa.eu/documents/10162/f9e7b269-87cd-fc26-1a8e-b8c8b6e40c08

[7] See https://ec.europa.eu/transparency/comitology-register/screen/documents/090483/1/consult?lang=en

[8] See https://echa.europa.eu/documents/10162/a59647fb-fcc5-869b-10d4-c14258bbea1d.

[9] See https://echa.europa.eu/registry-of-restriction-intentions/-/dislist/details/0b0236e18663449b.

[10] See https://www.reach-clp-biozid-helpdesk.de/SharedDocs/Downloads/DE/REACH/Verfahren/Beschr%C3%A4nkung/Consultation-PFAS.pdf?__blob=publicationFile&v=1.

contains at least one fully fluorinated methyl (CF3-) or methylene (-CF2-) carbon atom (without any H/Cl/Br/I attached to it).", though there are exceptions.

The scope of the proposed ban includes all uses of PFAS, regardless of whether they are specifically assessed or mentioned in the restriction proposal, unless a specific derogation applies. Figure 2.1 below reproduces Table A.1 from Annex A to the restriction proposal, which lists the PFAS applications and the level of scrutiny they received in the restriction proposal development process[11].

PFAS applications			
PFAS manufacture	Textile, upholstery, leather, apparel and carpets (TULAC)	Food contact materials and packaging	Metal plating and manufacture of metal products
Consumer mixtures	Cosmetics	Ski wax	Applications of fluorinated gases
Medical devices	Transport	Electronics and semiconductors	Energy sector
Construction products	Lubricants	Petroleum and mining	Waste stage PFAS applications
Laboratory equipment & filtration	Plant protection products and biocides	Chemical industry	Firefighting foam
Medicinal products	Plastics (other than packaging) and rubber/elastomer production (including flame retardants)	Pyrotechnics	Personal care products other than cosmetics
Fracking (currently hardly applicable in EEA)	Immersion cooling (currently hardly applicable in EEA)	Defence industry	Printing inks
Cement industry	Professional cleaning and polishing	Other niche applications	Uses (yet) unknown

- Green uses are researched in detail
- Blue uses are researched in general
- Orange uses not researched in detail
- Purple use: Separate restriction proposal

Figure 2.1 Overview of PFAS applications and the level at which they were researched (reproduced from Annex A to the PFAS restriction proposal)

The restriction proposal includes a number of proposed derogations and derogations subject to reconsideration. These are for most of the uses and applications of PFAS that were researched in detail. The broadness of their scope varies, from very specific single applications to broader sectors (e.g., for petroleum and mining industries).

2.2 Aim of the report

The Fluoropolymers Product Group of PlasticsEurope (FPG) is participating in the public consultation on the proposal for a restriction of PFAS, which was initiated by ECHA and runs until 25 September 2023. As part of their response, FPG wants to present relevant data on the uses / applications of fluoropolymers in the EU, including information on tonnages of fluoropolymers used, the availability of suitable alternatives, and the socioeconomic benefits of the continued use of fluoropolymers for the EU society. The input of FPG is being submitted in two separate reports.

This is the second of two reports submitted by FPG. In the first response, which was submitted to the open public consultation on 07 July 2023, with comment number 6150, the aim was to highlight the broad range of

[11] Annex A to the Annex XV Restriction report for Per- and poly-fluoroalkyl substances. Available online at: https://echa.europa.eu/documents/10162/f71f3bed-e48d-5004-d195-e293c38d0602, accessed on 29 May 2023

fluoropolymer uses in the EU and the difficulty in identifying and implementing suitable alternatives for most of these uses. The summary from that report can be found in Chapter 3 of this report, for reference.

This report aims to provide a high-level overview of the importance of fluoropolymers for EEA society and economy and the potential socioeconomic impacts of the proposed restriction and it complements the first one. Where relevant, references are made to relevant sections of the first report.

2.3 Scope of the report

The restriction proposal defines PFAS as "*Any substance that contains at least one fully fluorinated methyl (CF3-) or methylene (-CF2-) carbon atom (without any H/Cl/Br/I attached to it).*"[12] There are many families of polymeric PFAS (fluoropolymers) manufactured and used in the EU as compounds or as fully formed articles. They can be largely grouped under fluoroplastics such as PTFE and fluorinated elastomers, while perfluoropolyethers is another family of FP with wide use.

As part of the public consultation, ECHA is requesting any data that could help them and the dossier submitters to inform their opinions and amend the restriction proposal. There are also more specific information requests, including:

1. Emissions in the end-of-life phase.
2. Impacts on the recycling industry.
3. Tonnage and emissions for the proposed derogations.
4. Information on alternatives, substitution potential and timelines, and socioeconomic impacts of non-use for uses that are not examined in detail in the restriction proposal.
5. Information on alternatives, substitution potential and socioeconomic impacts of non-use for the potential derogations that are marked for reconsideration.
6. Similar information as items 3 and 4 for any other use of PFAS, including fluoropolymers.
7. Degradation potential of specific PFAS groups

This report will mainly focus on points 4-6 above, and more specifically on outlining the diverse societal benefits enabled by the use of fluoropolymers in sectors of the EEA economy as well as their huge economic significance.

The geographic scope of this document will be the EEA, the area where the PFAS restriction will apply. The report will apply to fluoropolymers manufactured, imported and used in the EU, either as such, in mixtures or in/on articles, by the members of FPG that participated in the provision of information.

An extensive stakeholder survey, covering the FPG member companies participating in the study and downstream users of fluoropolymers in the EEA was undertaken in February and March 2023. The FPG consultant prepared two questionnaires, one for FPG members and one for downstream stakeholders. The questionnaires included questions on the uses of fluoropolymers, their function, assessment of potential alternatives and the socioeconomic impacts in case no derogation was granted for uses. The survey received a total of 144 responses, eight from FPG members and the remaining 136 from downstream stakeholders. The responses were collated and the aggregated relevant information is included in this report.

[12] Annex XV Restriction report – Proposal for a submission: Per- and polyfluoroalkyl substances (PFASs). Available online at:.https://echa.europa.eu/documents/10162/f605d4b5-7c17-7414-8823-b49b9fd43aea, accessed on 07 September 2023

3. SUMMARY FROM PREVIOUS REPORT ON ALTERNATIVES AND SUBSTITUTION POTENTIAL

3.1 Background information on the report on uses and alternatives (Previously submitted report)

On March 22, 2023, ECHA formally published the Annex XV report for the EU REACH PFAS restriction proposal and kicked off the six-month open public consultation giving all stakeholders the opportunity to submit information on their PFAS uses and the availability of alternatives. The public consultation is going to last until 25 September 2023.

The Fluoropolymers Product Group of PlasticsEurope (FPG) prepared the first report for submission to the public consultation on the proposal for a restriction of PFAS, by providing relevant data on the uses / applications of fluoropolymers in the EU, including information on tonnages of fluoropolymers used, and the availability of suitable alternatives. Within the first report, the aim was to highlight the broad range of fluoropolymer uses in the EU.

The information presented in the first report was collected via literature review of publicly available sources and through an extensive survey with FPG member companies, i.e., the fluoropolymer manufacturers, and downstream users of fluoropolymers, which received responses from over 130 companies in total.

3.2 Applications of fluoropolymers

Fluoropolymers are a versatile and durable group of materials, which are used in a very broad range of industry sectors, primarily for professional and industrial applications. They can be grouped in three main categories, namely fluoroplastics (PTFE, ETFE, PVDF, PFA, etc.), fluorinated elastomers (FFKM, etc.), and specialty fluoropolymers (PFPE as lubricant, amorphous fluoropolymers, fluorinated ionomers).

Fluoropolymers exhibit a combination of properties that make them the only suitable material for a broad range of applications, where durability to extreme temperatures, aggressive chemical agents and mechanical stress is essential, together with oil- and water-resistance, non-stick properties and / or low coefficient of friction. As a result, they are often the only type of materials suitable for use in applications where such harsh, extreme conditions are expected to be present.

Their versatility allows them to be used in different forms, such as:

- Coatings to protect a substrate from water, oil, chemicals or UV radiation, or to offer a low-friction surface in construction and transportation.
- Moulded sealing components to prevent leakage of hazardous or infectious agents in processes.
- Filter membranes, ensuring removal of all potential contamination in ultraclean manufacturing environments (e.g., in semiconductor manufacturing) or in the treatment of drinking water and wastewater.
- Ion-exchange membranes that are used in electrochemical processes, in the chemical industry and for power generation (e.g., fuel cells, hydrogen generation).
- Lubricants or lubricant additives in very demanding transport and industrial applications.

According to information provided by FPG members, in 2022 the quantities of fluoropolymers manufactured or imported in the EU were in the range of 40,000 – 95,000 tonnes. This indicates an increase to the volumes declared for 2020 in a previous SEA document on fluoropolymers, but it is within the range of fluoropolymer usage assumed in the PFAS restriction proposal. Transport (road, off-road and aerospace) applications accounted for the highest usage of fluoropolymers, followed by the chemical processing industry. Other critical sectors of fluoropolymer applications are energy (including power generation, Li-ion batteries, and hydrogen technologies), electronics and semiconductors, food processing (food contact and processing materials, cooking surfaces, packaging), medical devices, petroleum and mining, military and defence, technical and non-technical textiles, and water and wastewater treatment.

3.3 Analysis of alternatives

The fields of application for fluoropolymers are variable, but one common parameter is that fluoropolymers are chosen due to their superior performance in applications where other solutions are not available or would have significantly worse performance, leading to significant safety concerns, and need for more frequent maintenance or replacement due to failures. In some cases, such reduced performance would not be accepted by the final users of an article or the operators of a process.

Many of the fluoropolymer applications are in sectors that are governed by strict industry standards and regulatory processes, to ensure a high level of safety and performance, for the benefit and protection of the public. Such sectors are aerospace and transportation, construction, medical devices, electronics, food processing, and water and wastewater treatment.

Other manufacturing processes also need to ensure a high level of cleanliness and / or safety for both the workplace and the environment. For example, the chemical processing sector needs to prevent leakage of hazardous chemicals from transfer and processing equipment, such as piping, vessels, pumps and valves. Fluoropolymer linings, coatings and seals are often the only suitable option. Furthermore, semiconductor, pharmaceutical, medical device and some fine chemical manufacturing processes need very clean environments, which can only be achieved through the use of fluoropolymer coatings or membranes in filters. Fluoropolymer lubricants are also used in a broad range of applications where harsh conditions are expected and other materials cannot meet the performance and safety requirements.

In this broad range of applications, fluoropolymers are the material of choice, and, in many cases, required by the industry standards. Alternative materials cannot provide the combination of properties exhibited by fluoropolymers, as they cannot display the required resistance to a wide range of temperatures, and degrade in presence of aggressive chemicals (e.g., petroleum products, caustic chemicals) or other contamination.

It must also be noted that fluoropolymers are usually more expensive than the potential alternative materials. The fact that they are preferred over cheaper materials, especially in some very cost-sensitive industries, such as chemical processing and transportation, is a strong indication that the potential alternatives are not suitable for the particular uses.

3.4 Conclusion

Overall, fluoropolymers are materials with a unique combination of properties that are used in a broad range of applications where harsh conditions are expected. They are critical for the safe use of equipment and for maintaining ultra clean manufacturing and operating environments, with no leakage or contamination over very long lifespans. Their continued use in those applications is necessary, as they are outperforming alternatives and should a potential alternative be identified, substitution may not be feasible without several years of testing and qualification.

While work on substitution is ongoing, and potential alternatives have been identified for some applications, it is unlikely that it will be possible to replace fluoropolymers in all applications in which they are currently used and certainly not within the time frames envisaged by the PFAS restriction proposal. The demanding specifications in these sectors mean that substitution will be achieved only through a long, structured process, and via rigorous testing. Considering the current status of alternatives and the unique combination of properties exhibited by fluorolymers in demanding applications, where safety and performance are a priority, it is very likely that fluoropolymers will need to continue being used for more than 10 to 15 years.

Table 3.1 Summary of fluoropolymer applications, status of alternatives, and substitution potential

Application	Indicative uses	Fluoropolymers used (not exhaustive)	Status of alternatives	Substitution potential
Transport, including automotive and aerospace	Fuel tubing and hose, engine oil and drivetrain seals (O-rings, gaskets), O-rings, seals, gaskets, ice-phobic coatings on helicopter rotor blades, window shades Exhaust gas pipes. Fuel cell membranes Oxygen, NO_x sensors, emission control systems. Pedal, battery, oil, radar, rain-light sensors Transmissions seals, thermal management systems Transfer or compression moulded automotive fuel Wires and cables Signal, control and power wires and cables insulated with fluoropolymers in military and civil aviation. Foams in aircraft insulation Electroluminescent lamps	Poly(TFE-ter-VDF-ter-PMVE), Poly(TFE-ter-PMVE-ter-VDF), Copolymers of tetrafluroethylene and propylene, FKM, FFKM, PVDF, PTFE, ETFE, FEP	Technical requirements and OEM specifications do not allow use of alternatives in harsh conditions (e.g., temperatures above 200°C, exposure to oils and fuel). Alternative rubbers cannot meet resistance to broad range of temperatures and to chemical agents in applications such as cable jacketing (for power transfer and sensors) and sealing.	The extreme performance requirements and specifications, combined with long qualification and certification processes make substitution of fluoropolymers in transport applications extremely difficult. Alternative development and qualification, process validation and certification and subsequent scale up and commercialisation of the alternative can be as long as 10 – 15 years or even longer in some cases (e.g., in aviation applications), even considering that a potential alternative has been identified.
Chemical processing	Fluid handling systems, Pipes (solid pipes and pipe linings), flue duct expansion joints. Seals, gaskets, valves, fittings, linings, filters, O-rings. PTFE-thread sealing tape. Tanks, lining of reaction vessels. Ion-exchange membranes (e.g., for chloralkali production). Wire and cable coatings for sensors, flowmeter tubes, and other electrical and electronic sensing and control equipment. Extrusion and moulding aids.	PTFE, FEP, PFA, ECTFE, EFPM, PVDF, fluorinated ionomers (ion exchange membranes), ETFE, FKM, and FFKM	Sealing from alternative rubbers cannot meet performance requirements for temperature (-40°C to 270°C), gas and chemical resistance. Chemical resistance is a main criterion, as alternative materials in pump, piping, etc. components cannot handle aggressive chemicals. Broad temperature compatibility is also essential for applications in flexible hoses and cryogenic media seals. These requirements	Alternative materials used in chemical processing cannot meet the high stability and performance requirements in chemical processes. In addition, any change in material requires long R&D, qualification, validation and commercialisation procedures before a suitable alternative is Industry stakeholders expect that such procedures can take several years, depending on the application, provided that a

Application	Indicative uses	Fluoropolymers used (not exhaustive)	Status of alternatives	Substitution potential
			can only be met by fluoropolymers. The alternatives to PEM cells in the essential chloralkali manufacturing industry use very hazardous materials (asbestos and mercury) and are also less energy efficient than membrane cells.	suitable alternative has been identified.
Construction	Wire & cable insulation, plenum cable insulation, Architectural protective and decorative coatings (e.g., on bridges), laminates, resistant paints, anti-graffiti and antifouling coatings, surface treatment in natural stone, metal, glass, plastic Bridge and offshore pad bearings Greenhouse films PTFE-thread seal tapes for pipes	PTFE, PVDF, PEF, PFA, ETFE	Potential alternatives in construction and architectural applications have worse performance (In plenum application fire safety performance can be unacceptable) than fluoropolymers and would be unsuitable where harsh conditions (environmental, mechanical) are expected. Alternative agricultural coatings have lower durability than fluoropolymers, which would require more frequent re-coating or replacements, with higher environmental load.	Substitution for construction and architectural applications, including PTFE-thread seal tapes depends heavily on stability testing over several years (6 to 12).
Energy, batteries and hydrogen	Solar panel coatings, O-rings, seals, gaskets, proton exchange membranes in fuel cells, in alkaline electrolysers and for hydrogen production via electrolysis, binder materials in the electrodes, both anode and cathode, and as a component of the gas diffusion layers (GDLs).	PVDF, Poly(TFE-ter-PMVE-ter-VDF), PTFE, ETFE, FKM, FFKM, other fluorinated elastomers, FEP	Some low energy alternatives for batteries are available, but they are not suitable for all applications, especially those that have space limitations, such as in transportation. In general, for Li-ion battery binders, the potential alternatives will require further testing and	The limited suitability of potential alternatives (due to durability and performance) for these applications and the long R&D and qualification procedures make substitution of fluoropolymers very difficult. For hydrogen applications (e.g., electrolysis membranes),

Application	Indicative uses	Fluoropolymers used (not exhaustive)	Status of alternatives	Substitution potential
	Infrastructure for transport and storage of hydrogen (lining materials, seals etc.), seals in liquid organic hydrogen carrier technologies. Potentially in turbines in flanged connections in order to mitigate leakages, in power generation using H_2. Binders in electrodes of batteries, separator coatings, additives in the electrolyte, gaskets/seals, pipes, valves and sealings in the battery itself, manufacturing of positive electrodes for Li-ion cells Solar panel and wind turbine blade coatings.		development before they can meet the performance requirements. For ion-exchange and electrolysis membranes used in hydrogen production, non-fluorinated alternatives still have worse durability and much shorter lifetimes than fluoropolymers. Sealing and cable jacketing alternative materials have lower resistance to temperature and chemicals than fluoropolymers, which make them unsuitable for use in applications with harsh conditions present.	alternatives may not be available for the next 10 years at least. For other applications, which also depend on meeting high performance requirements, substitution can also take many years.
Petroleum and mining	Chemical resistant components (e.g., seals) and coatings for extraction, transport and processing of petroleum and ores. Wire and cable insulation and covering Coating for sensors	FEP, PVDF, FKM, FFKM, FEP, PFA	Alternatives for applications in the petroleum and mining sector cannot meet the very high performance requirements for temperature (as high as 270°C), chemical and mechanical resistance. This appears to be recognised by the restriction proposal dossier submitters, who proposed a derogation for such uses. However, these performance requirements also extend to transport and processing of these chemicals and ores, with very extreme conditions often present.	The extreme performance requirements and specifications, combined with long R&D and qualification make substitution of fluoropolymers in petroleum and mining applications extremely difficult. Stakeholders expect that substitution can take as long as 10 years, provided that an alternative is available, which is not the case.
Food contact materials and packaging	Industrial, commercial and consumer cookware and bakeware	PTFE, PFPE, FEPM, PVDF, PFA	Alternative materials for cook- and bakeware do not have the combination of properties that	Food contact materials are heavily regulated and any FCM must

Application	Indicative uses	Fluoropolymers used (not exhaustive)	Status of alternatives	Substitution potential
	Water and oil-repellent coating on paper products and packaging (cans, bags, etc.) Conveyor belts for cooking and drying foodstuff Processing / polymerisation aids for plastic film production Process lubricants		fluoropolymers offer and may fail in durability, non-stick, and temperature, chemical and abrasion resistance. In addition, no suitable alternatives are available in the EU for processing aids.	meet several quality and safety standards. Any change would include identifying an approved FCM and running a series of durability and migration tests. The overall process can take at least three years, provided that the selected alternative is successful at all stages. High performance and safety requirements for FCM and the current status of alternatives means that substitution would take significant longer than that.
Electronics and semiconductors	Components of electronic devices (e.g., Hard disk drives), Semiconductor manufacturing (e.g., HEPA filters, wet processing equipment components) O-rings, seals, gaskets, parts and tubing used in the semiconductor processing industry, Welding and soldering agent, Insulation in wires and cables, Coatings, batteries and smart devices Powder coating for phone and tablet screens. Anti-reflective coatings for semiconductors Sensor applications (industrial, automotive, measuring and analytical)	PVDF, PFA, PFPE, PTFE FKM, FFKM, ECTFE, FEP	Alternatives for electronics and semiconductor applications cannot fulfil the temperature and chemical resistance required. The semiconductor industry in particular requires ultra-high purity and thermal resistance, which cannot be met by alternatives. Non-fluoropolymer alternatives are likely to cause contamination to products. Alternatives do not have the combination of properties offered by fluoropolymers and fail in temperature, chemical or mechanical resistance requirements. Analytical instruments and sensors also require high precision and cleanliness, and	The lack of alternatives for semiconductor applications, together with long R&D and qualification procedures make substitution in these applications extremely difficult. It can take as long as 10-15 years to develop an alternative to fluoropolymers, assuming that a suitable alternative is identified and there are no setbacks during the qualification and verification. Electronic equipment also has to carry out lengthy verification and validation testing to meet the very high performance and safety requirements by customers. This process can also take several years, especially considering that for many applications there are no alternatives.

Application	Indicative uses	Fluoropolymers used (not exhaustive)	Status of alternatives	Substitution potential
			only fluoropolymers can offer the required level of purity.	In addition, some products (e.g., cables and other electrical / electronic equipment) may need to receive third party approvals for CE Mark or other certifications by independent third parties, which is a process that can take several years, subject to the third party's availability.
Water and wastewater treatment	Hollow fibre micro- and ultra-filtration water & wastewater treatment membranes Water piping	PTFE, PVDF	Experience with other materials such as polyether sulfone or chlorinated polyethylene have shown that the lack of flexibility, cleanability and chemical resistance result in short life expectancy and high operating cost for municipal and industrial users. Such materials may be in use for some low risk applications, but not for water with high levels of contamination such as surface water, urban WWTP and industrial wastewater. Fluoropolymers enable these waters to be used or reused for drinking water, utility water, process water or irrigation Ceramic based membranes are not suitable for large scale water and wastewater applications with space constraints.	Potential alternatives are not suitable for demanding water and wastewater applications where high levels of contamination are present and any substitution could take several years (as long as 5-10, but most likely over 15). Substitution is made even more difficult as the alternatives would require more space, which is not possible for most current installations, and many more frequent replacements.
Lubricants	High performance Lubricants (stable and inert) for applications in the aerospace, military, automotive, electronics, semiconductor, textile, chemical, paper, plastic and nuclear industries. Also in wind turbines as, due	PFPE, PTFE	Alternatives cannot meet the high performance requirements in the various applications (automotive, chemical processing industry, food processing, drinking water treatment), as they have worse	Lack of high-performance alternatives for most applications makes substitution difficult. Furthermore, qualification and testing requirements for each

Application	Indicative uses	Fluoropolymers used (not exhaustive)	Status of alternatives	Substitution potential
	to their inaccessibility, they cannot be serviced regularly. High performance lubricants for engines and machinery. Lubrication for vacuum pumps, high-pressure oxygen equipment. Non-stick coatings as dry film lubricants in baked goods production, food processing, automotive and transportation, high-temperature kitchen equipment, medical equipment.		durability against chemicals and temperature and are dependent on the temperature, which is not the case for fluoropolymer-based lubricants.	application can take several years, depending on the industry sector.
Medical devices and pharmaceuticals	Biomedical devices Other medical devices, e.g., catheters, stents, heart patches, sutures, seals, lubricants, filters or surface treatment Coating in primary packaging components, coating for metered dose inhalers Analytical equipment and laboratory applications.	PTFE, ETFE, PVDF, FEP, FKM, PFA	Alternatives do not have the combination of thermal, chemical and mechanical resistance, together with the biocompatibility, offered by fluoropolymers. Particularly for cables used in medical equipment and in invasive procedures (e.g., endoscopy, surgeries), alternative rubbers are not conducive to the miniaturised equipment needed to perform them (e.g., endoscopy cables, guiding wires). Sealing and filtering equipment, relevant to the sensitive and low contamination tolerant manufacturing processes in these sectors, also do not have suitable alternatives, as discussed in sections on semiconductors, chemical processing, and petroleum and mining.	Medical devices and pharmaceuticals are heavily regulated products and any change in the product or the manufacturing process must undergo lengthy testing and qualification procedures and receive approval and certification from competent third parties. These processes could take 10-15 years to develop an alternative to fluoropolymers, but that could depend on the application, and on no unacceptable results during validation and approval.
TULAC	Waterproof and stain repellent clothing	PTFE	Alternatives for filtering media cannot meet the performance	Substitution in demanding applications may not be possible

Application	Indicative uses	Fluoropolymers used (not exhaustive)	Status of alternatives	Substitution potential
	Chemical resistant PPE, fabrics, and high-performance textiles Membranes used as filtering media in applications with very low contamination tolerance (e.g., semi-conductors, pharmaceuticals, medical devices, chemical processing) Coated fabrics for architectural applications, tents and furniture		and safety requirements, as discussed in other applications (e.g., semiconductors, chemical industry). Alternatives do not appear to be available for more demanding applications (e.g., heavy rain resistance or dynamic water repellence, and high alcohol repellence needed in medical uses), where only the superior performance of fluoropolymers is suitable.	in the short term, due to non-availability of suitable alternatives. For some applications, e.g., in pharmaceutical and medical devices, this can take much longer, as explained in the relevant section.
Metal plating and manufacturing of metal products	Noise suppression, anti-foam agent Electrical insulation and sealing in metal heating processes. Noise reduction and as dry bearings in metal product manufacturing processes.	PTFE	As per the information in the annexes to the restriction proposal, there is limited information available on alternatives for hard chrome plating.	Substitution activities for such applications would relate to the end product, which could be used in the transport, chemical, etc. sectors. Considering the discussion for the relevant applications, substitution of fluoropolymers in hard chrome plating applications can be long.
Cosmetics, consumer mixtures, ski wax and other uses	Polishes and waxes for stone surfaces for consumers and professionals Cosmetic applications (dental floss, perfume dip tips) Ski waxes	PTFE, FFKM	The dossier submitters mentioned strong evidence for the presence of technically feasible alternatives for consumer mixtures (e.g., for cleaning mixtures, waxes and polishes, dishwashing products, windscreen fluids for cars, and guitar strings), cosmetics and ski waxes. The stakeholder survey carried out for this report did not produce any additional information.	Considering the status of alternatives for these uses, as identified in the annexes to the restriction proposal, it is expected that substitution will be possible for most, if not all the applications.

4. SOCIOECONOMIC IMPACT ASSESSMENT

4.1 Market summary

The fluoropolymer market in 2020 has been described in a previous SEA document, which was submitted during the earlier Call for Evidence and is also available at the FPG website[13].

That SEA includes two tables breaking down the usage and value of fluoropolymers across the different market sectors. The previous SEA document presented two breakdowns by sector, the first to match an earlier report from 2016-17 and the second one to match the studies that were supporting the PFAS restriction proposal in 2020. These tables are reproduced below.

Table 4.1 Sales of fluoropolymers in the EU in 2020 per sector of use, as per 2016-17 report (reproduced from Table 3.6 of previous FPG SEA)

Sector of use	Total quantities sold (t)	Total value (€ million)
Chemical and power	11,000	220
Food and pharmaceutical industry	2,000	30
Electronics	3,500	70
Transport	15,500	280
Renewable energy	500	20
Cookware	2,000	30
Medical applications	500	20
Textiles and architecture	1,500	40
Other sectors	3,000	60
Total	40,000	740

Table 4.2 Sales of fluoropolymers in the EU in 2020 per sector of use, as per sector breakdown in studies supporting PFAS proposal (reproduced from Table 3.7 of previous FPG SEA)

Sector of use	Total quantities sold (t)	Total value (€ million)
Chrome plating	0	0
Consumer mixtures	1,000	10
Cosmetics	Confidential	Confidential
Construction	4,500	90
Electronics	4,000	80
F-gases	0	0
Firefighting foams	0	0
Food contact materials	3,000	50
Lubricants	1,500	30
Medical devices	500	20
Petroleum	3,500	70
Mining	Confidential	Confidential
Ski wax	Confidential	Confidential
Textiles	500	10
Transportation	16,000	280
Other sectors	5,500	120
Total	**40,000**	**740**

The total usage of fluoropolymers in the EU (manufactured and imported) in 2020 was estimated at approximately 40,000 tons per year, and the value of the products at approximately € 750 million. Fluoropolymer sales exhibited a downward trend compared to 2015. The restriction proposal estimated the total volume of PFAS placed on the market in 2020 at between 72,000 and 185,000 tons. It is understood that these numbers also include side-chain fluorinated polymers.

[13] Wood (2022). Update of market data for the socioeconomic analysis (SEA) of the European fluoropolymer industry. Available online at: https://fluoropolymers.plasticseurope.org/application/files/1216/5485/3500/Fluoropolymers_Market_Data_Update_-_Final_report_-_May_2022.pdf, accessed on 21 August 2023

It should be noted that Table 4.2 does not include a chemical industry sector breakdown, but it is understood that the quantities presented in Table 4.1 are distributed in the different sectors, most likely in the "other sectors" category.

As part of this 2023 report, an attempt was made to update these numbers with more recent data collected by FPG member companies. The updated volumes are collected in Table 3-2 of the previously submitted report to the OPC and were estimated at between 40,000 and 95,000 tons in 2022. The updated estimated revenue from fluoropolymers in 2022 resulted in a much higher number of approximately € 1 – 3 billion, as shown in Table 4.3.

Table 4.3 Value of fluoropolymers sold in the EU in 2022 per sector of use

Sector of use	Fluoropolymers sold in EU in 2022 (in € million)	Future market trends forecasts
Transportation and aerospace (excluding lubricants)	250 – 500	The demand from the transportation (land and aerospace) sector is expected to remain strong in the future, with the overall market showing slow but sustained growth. This trend is supported by the increased demand for EVs and the emergence of zero emission technologies such as hydrogen fuel cells in commercial vehicles. The hydrogen industry is expected to have a strong influence on fluoropolymer demand, as discussed in the energy applications section. Dossier submitters have assumed a growth rate of approximately 1%, which seems low, considering the increasing demand for electric vehicles and hydrogen fuel cells.
Industrial applications (chemical industry, excl. lubricants)	100 – 250	FPG members expect a slow but steady growth in the demand for fluoropolymers in the chemical processing industry. The demand is expected to be stronger for specific sectors that rely extensively on fluoropolymers, such as the chloralkali sector, which requires fluorinated ionomer membranes. Dossier submitters have not considered at all this very important market sector in the restriction proposal. For calculation purposes, a modest growth of 2% is assumed in this report.
Construction materials and products	100 – 250	FPG members expect the construction market for fluoropolymers to grow in the short- and long-term. The forecasted growth can be attributed to the overall construction sector growth as well as to expected increased demand for protective coatings. An annual growth rate of 5-10%, at least in the short-term is expected. The dossier submitters assumed a strong growth until 2030, with a slowdown in the years after that (2.5% until 2040 and 1% afterwards).
Energy applications, including batteries and hydrogen	150 – 500	The demand for fluoropolymers for energy applications is expected to grow significantly in the short- and long-term, stimulated by the EU's electrification and decarbonisation targets for 2030 and 2050. Market segments that are expected to drive this growth are electrolysis installations for green hydrogen production, photovoltaic sheet coating, and fuel cell PEM. In addition, use of fluoropolymers as binders in batteries is also expected to increase due to the increased need for storage capacity and EV demand. The overall growth is expected to be significant. Dossier submitters have assumed a 10% growth increase for energy uses in the EU, particularly as a result of the EU's Green Deal and decarbonisation goals. The hydrogen targets (40GW electrolysis capacity by 2030) is among the main drivers for this trend.
Petroleum and mining	50 – 150	The overall fluoropolymer demand for petroleum and mining applications is expected to experience a slow growth in the short-term, but this trend may stabilise or even reverse in the mid- and long-term. The demand for different fluoropolymer products differs, and will depend on the increased regulatory specifications e.g., for reduced emission and the need for increased performance. The EU Green Deal and decarbonisation goals may also impact the petroleum market for fluoropolymers, as the extraction operations may fall in the coming decades. Dossier submitters expect petroleum and mining use to decline in the coming decades, with oil and gas infrastructure becoming decommissioned. Nevertheless, they have assumed a 1% growth rate for their assessment.

Sector of use	Fluoropolymers sold in EU in 2022 (in € million)	Future market trends forecasts
Food contact materials (FCM) and packaging (excl. lubricants)	50 – 150	In general, FPG members expect the overall FCM market for fluoropolymers to generally remain stable or contract in the short- and long-term. Individual applications can show different trends, but the overall expectation is declining. This depends on the regulations for food and feed processing. Industrial use of fluoropolymers (e.g., as seals or processing aids) is expected to increase slightly to comply with stricter standards. Consumer usage is expected to drop as a result of the proposed restriction. Dossier submitters, on the other hand, expect a stronger increase for consumer cookware (6%) and a more contained one for industrial uses (1.5%).
Electronics and semiconductors	100 – 250	The general consensus is that the electronics and particularly the semi-conductor sectors are going to drive a strong growth trend for fluoropolymers. Fluoropolymers are essential for manufacturing of semiconductors. The increased digitalisation in the EU with more devices entering the market and the increase in semiconductor production in the region are expected to increase demand for fluoropolymers in the short- and the long-term. A growth rate of 10% per year as assumed by the dossier submitters is not unrealistic.
Water and wastewater treatment	10 – 100	FPG members expect the demand for fluoropolymers by the water and wastewater treatment sector to increase in the short- and long-term, mainly as a result of the expected increase in need for potable and clean water and the high water quality standards in the EU. Dossier submitters have not considered at all this very important market sector in the restriction proposal.
Lubricants	100 – 250	FPG members expect slow to no growth for their fluoropolymers intended for the lubricants market segment. This could be attributed to the expected drop in internal combustion engine (ICE) vehicles and the increase of demand for electric vehicles (EVs) in the mid- to long-term in the EU. The dossier submitters are assuming a strong growth until 2030, with a slowdown in the years after that (2.5% until 2040 and 1% afterwards).
Medical devices	50 – 150	Overall, medical device applications of fluoropolymers are expected to grow strongly (up to 10% per year) in the short- and long-term. This can be due to new applications of fluoropolymers, but it is also due to the ageing population of Europe, which is expected to increase the need for operations using such products (e.g., stents). The information provided by FPG members agrees in principle with what the dossier submitters have included in Annex E to the restriction proposal, though the dossier submitters assume a slightly lower growth rate at 5%.
TULAC (Textiles, upholstery, leather, apparel and carpets)	50 – 150	FPG members expect overall sales to drop in the mid- and long-term, mainly driven from companies moving away from consumer uses. Professional use for safety clothing is expected to have a steady increase. Dossier submitters expect an overall strong growth in the short-term (5-8% pa) and a slower one in the long term (1-2% pa)
Metal plating and manufacturing of metal products	0 – 150	Limited information available on growth. In general, it can be assumed to remain stable in the baseline scenario, even if some applications in harsh conditions exhibit growth.

Sector of use	Fluoropolymers sold in EU in 2022 (in € million)	Future market trends forecasts
		Dossier submitters assumed no growth.
Cosmetics and personal care	5 – 10	Overall, sales are expected to remain stable, according to information received from FPG members. Dossier submitters assumed no growth for the sector.
Ski treatment (waxes)	0 – 20	Limited information available from FPG members, but general consensus is that its usage will go down. Dossier submitters assumed a significant decline of 8% per year until 2030 and 1% between 2030 and 2040.
Consumer mixtures	0 – 10	Limited information available on market trends. In general, it can be assumed that any remaining consumer applications of fluoropolymers will remain stable. Dossier submitters did not consider any market trends.
Other	10 – 100	
Total	**1,020 – 3,000**	It is expected that the overall demand for fluoropolymers will increase in the short- and long-term, as a result of the EU's policies for decarbonisation, cleaner environment and adoption of new technologies. Climate change is also expected to influence many decisions into adoption of more efficient solutions (such as protective architectural coatings), which rely on fluoropolymer technology.
Notes: Upper limit intentionally high to ensure that the individual companies' revenue could not be back calculated		

4.2 Description of possible no derogation scenarios

4.2.1 Relevance of proposed and considered derogations to fluoropolymers

The PFAS restriction proposal is intended as a broad restriction, with a small number of specified categories that are specifically excluded from the restriction proposal (see paragraph 4 in the second column of the restriction proposal) and include uses that are covered by other legislations, such as biocidal and plant protection and pharmaceutical and veterinary active substances. There are 46 proposed and considered targeted time-limited derogations are included in the proposal.

The time-limited derogations are for specific applications and conditions. Table 4.4 presents the proposed and considered derogations in the proposal that are relevant to fluoropolymers along with the estimated relevant fluoropolymer quantities. The latter have been estimated based on publicly available information (e.g., in the restriction proposal annexes) and using a number of assumptions. To mitigate the uncertainty, ranges were used where data were limited.

Table 4.4 Estimation of fluoropolymer quantities covered by the proposed derogations

Sector of use	Total quantities (in t)	Share of quantities covered by proposed derogations	Share of quantities covered by considered derogations	Quantities not covered by a derogation (t)	Comments / Discussion
Transportation and aerospace	11,000 – 20,000	0%	10-25%	9,900 – 15,000	The definition of the considered derogation on transport applications 6(o) is unclear and may be open to conflicting interpretation by manufacturers and authorities. On one hand, companies could claim that all fluoropolymer components and coatings are essential for the safety of a vehicle, its passengers or the cargo. On the other hand, there may be cases where this is not perfectly clear. It seems safe to assume that all fluoropolymer uses in aviation (e.g., fuselage manufacturing, cable insulation, and cable conduit) are covered. Automotive / land transport uses are more uncertain. Therefore, a medium weight coverage should be assumed. It should also be noted that the considered derogation does not cover use of electrical or electronic systems or lubricants.
Industrial applications (chemical industry)	8,000 – 16,000	0%	0%	8,000 – 16,000	No derogations proposed for this use sector, and the use is not described at all in the restriction proposal documents.
Construction materials and products	5,000 – 10,000	0%	0%	5,000 – 10,000	No derogations proposed for this use sector
Energy applications, including batteries and hydrogen	5,000 – 10,000	0-10%	0%	4,500 – 9,000	The only proposed derogation for the whole energy sector is for PEM fuel cells. While this is an important use, it does not include other important fluoropolymer uses such as binders in Li-ion batteries, ionomers for hydrogen electrolysers, coatings in PV panels and wind turbine blades, as well as sealing in power plants, and cable jacketing. As such, the covered quantities by this derogation are expected to be very low.
Petroleum and mining	2,500 – 10,000	50 – 100%	0%	0 – 5,000	It appears that fluoropolymer applications in petroleum and mining are covered by this derogation. This does not appear to cover downstream refining and processing of the extracted resources, however, a high coverage rate is assumed for this derogation.

Sector of use	Total quantities (in t)	Share of quantities covered by proposed derogations	Share of quantities covered by considered derogations	Quantities not covered by a derogation (t)	Comments / Discussion
Food contact materials and packaging (excl. lubricants)	2,500 – 6,000	12.2 – 16.6%	3.1 – 4.2%	2,120 – 4,750	There is one proposed and one considered derogation, both of which relate to industrial / commercial applications of fluoropolymers in the food processing sector. According to the information in Annex A to the restriction proposal (section A.3.3), industrial applications account for 15.3-20.8% of the total quantities of fluoropolymers used in this sector of use. It is unclear, however, how much of it is used in industrial processes (proposed derogation) and how much for industrial and professional bakeware. Considering the extensive use of fluoropolymers in the food and feed processing industry, an 80/20 split will be assumed for this exercise.
Electronics and semiconductors	2,000 – 6,000	0%	11.3 – 22.5%	1,780 – 4,850	Annex A to the restriction proposal (Section A.3.12.2), estimates that 45% of fluoropolymers are used in semiconductors and 55% in other electronics. According to the submission of the European Semiconductor Industry Association to the OPC (response No 4449), "*…the semiconductor industry is very reliant on PFAS materials. Those materials are used in manufacturing process chemistries, in specific semiconductor functional layers and packages, semiconductor manufacturing equipment, semiconductor manufacturing infrastructure, and support equipment in addition to the semiconductor device*". The considered derogation on semiconductors refers to the manufacturing process, and it is not clear if it also covers the equipment, site infrastructure and final products (semiconductor chips), which may contain fluoropolymers. As it stands, it could result in most of the fluoropolymers used in "packaging" of semiconductors, as well as components of manufacturing equipment (such as sealings and linings) not being within scope. Therefore, a mid-range coverage (25-50%) is assumed for this derogation.

Sector of use	Total quantities (in t)	Share of quantities covered by proposed derogations	Share of quantities covered by considered derogations	Quantities not covered by a derogation (t)	Comments / Discussion
					There is no derogation for electronics, though some may be covered in derogations for other applications (e.g., in transportation), the majority seems to be out of scope.
Water and wastewater treatment	1,000 – 6,000	0%	0%	1,000 – 6,000	No derogations proposed for this use sector, and the use is not described at all in the restriction proposal documents.
Lubricants	500 – 2.500	25-50%	0%	375 – 1,250	The wording in the proposed derogation is unclear and may lead to conflicting interpretations by the industry and the authorities. 'Harsh conditions' are not specified quantitatively, and the "safe functioning and safety" of equipment could be interpreted too broadly or too narrowly. As such, a conservative impact of 25-50% of fluoropolymer lubricants are considered covered.
Medical devices	300 – 2.000	25-50%		225 – 1,000	The use of fluoropolymers in medical devices is very extensive, mainly as coatings, but they are also used as component materials. The restriction proposal includes a number of proposed and considered derogations for use of PFAS and fluoropolymers in medical devices. The specific quantities of fluoropolymers used in these particular applications are not clear. There is a considered derogation 6(j) on "coating applications for medical devices other than Metered Dose Inhalers", which is the main application of fluoropolymers. Also considering that some uses of fluoropolymers (e.g., in laboratory equipment) do not seem to be covered by a derogation, it is assumed that 25-50% of fluoropolymer use in medical devices will be covered by the proposed and considered derogations.
TULAC (Textiles, upholstery, leather, apparel and carpets)	800 – 2,000	5.4 – 13.6%	0.8 – 5.1%	750 – 1,630	There are proposed derogations for some PPE categories and for technical textiles. According to the information in Annex A to the restriction proposal (section A.3.3), professional apparel accounts for 15.5-17.3% and technical textiles for 15.4-20.3% of fluoropolymers used in textiles. PPE are an unspecified share of professional apparel and approximately 20% of PPE are for Category III hazards. It can be assumed then that the professional apparel derogations 5(b) and (c) cover 10-20% of the fluoropolymer use in that group.

Sector of use	Total quantities (in t)	Share of quantities covered by proposed derogations	Share of quantities covered by considered derogations	Quantities not covered by a derogation (t)	Comments / Discussion
					The technical textiles use in filtration and separation media where both oil and water repellence are required are a smaller subset and do not cover the whole technical textile usage. The actual share is unclear, so a conservative 25-50% share is assumed. The considered derogation for use in engine bays in cars is a relatively small share of technical textiles, so it is assumed to account for 5-25% of the respective usage.
Metal plating and manufacturing of metal products	20 – 200	0%	5-25%	15 – 150	The considered derogation is for the use of PFAS in hard chrome plating, where fluoropolymers have very few, if any applications. Most fluoropolymers in this use sector appear to be used in manufacturing of metal products, which do not have a derogation. It is possibly that fluoropolymers may be used in plant equipment as seals or other components, but this could not be confirmed. Nevertheless, following a more conservative approach, a 5-25% relevance will be assumed.
Cosmetics and personal care	100 – 1000	0%	0%	100 – 1,000	No derogations proposed for this use sector
Ski treatment (waxes)	0 – 20	0%	0%	0 – 20	No derogations proposed for this use sector
Consumer mixtures	1 – 100	0%	0%	1 – 100	No derogations proposed for this use sector
Other	1,000 – 2,000	0%	0%	1,000 – 2,000	No derogations proposed for other use sectors
Total	**40,000 – 95,000**			**34,766 – 77,750**	

In total, the proposed derogations would only cover **13 - 17%** of the fluoropolymer sales volumes in the EEA by FPG members.

Some use sectors of particular interest are:

- The **chemical processing industry**, which accounts for a large share of the manufactured and sold fluoropolymers in the EU, has not been considered at all in the restriction proposal and there are no explicit derogations or exemptions. As such, the whole usage of fluoropolymers in this sector, which includes seals, pipe and vessel linings, potable, waste- and industrial water treatment membranes and also filters and ion-exchange membranes, are currently not covered by a derogation.
- In addition, there is a need for PTFE micropowders for manufacturing using high-performance resins, such as PEEK, PAI and PI. Furthermore, composite materials and other high temperature polymers that require mould release agents are not covered by the proposed derogations. However, they constitute a significant share of fluoropolymer usage and can have a significant impact in the output and quality of high-performance polymer manufacturing.
- **Energy applications** only have a proposed derogation for PEM fuel cells, which is only a small part of the extensive applications of fluoropolymers in the sector. This leaves most of the fluoropolymer usage for energy applications not covered by a derogation and, ultimately, lost if the scope of the currently proposed derogation is not changed. Such uses include binders in batteries, electrolysis membranes for hydrogen production, seals and wiring for conventional and nuclear power plants. Seals and wiring are critical to the safety of nuclear power plants, which generated 21.9% of the EU's electricity in 2022[14].
- The **transport and lubricant** derogations lack sufficient clarity, which risks conflicting interpretations by different actors, and could result in many applications not being covered by a derogation.
- **Construction** applications are also not covered by derogations, despite the difficulty to identify and implement alternatives for critical uses, such as electrical installations, bearings for bridge and wind turbine bases, and protective (conformal) coatings.
- The partial derogation for **semiconductor manufacturing**, which seems to exclude the range of uses and materials needed for manufacturing as well as in any semiconductor products placed on the market as well as those that can be found in the whole range of electronic and other consumer products. This leaves a large share of fluoropolymers used by the industry not covered by a derogation.

Overall, some of the most critical and extensive uses of fluoropolymers, for which substitution is very difficult, if not impossible, within the restriction proposal's derogation 6.5- or 13.5-year timeframes, are not covered by the proposed or considered derogations and will need to stop within 18 months of the restriction's entry into force unless taken into scope in the next phase of the PFAS restriction proposal process.

4.2.2 Scope of impacts for the fluoropolymer industry

The proposed restriction as it stands would seriously limit the operations of fluoropolymer manufacturers, as it will prohibit the manufacturing and placing in the market most of their output. As estimated in Section 4.2.1, more than 80% of the fluoropolymer manufacturers sales would be impacted by the currently proposed restriction.

This must be considered with the lack of alternatives for the majority of the uses, even those that do not have a proposed derogation, as discussed in Chapter 3 of the previously submitted response by FPG. In addition, the long times needed to identify, develop and qualify alternatives for most applications do not allow for sufficient development of these alternatives. The absence of alternatives can even affect the uses of fluoropolymers under the derogations that have been proposed. It is very likely that suitable alternatives may not be available even after the proposed derogation periods expire. As a result, the current restriction proposal carries a

[14] European Council website – Infographic: How is EU electricity produced and sold? Available online at: https://www.consilium.europa.eu/en/infographics/how-is-eu-electricity-produced-and-sold/#:~:text=In%202022%2C%2039.4%25%20of%20electricity,Coal%3A%2015.8%25, accessed on 07 September 2023

significant risk that function of critical operations and manufacture of important products in the EU will not be possible without broader, or more specific and detailed, and longer derogations.

Such a large restriction will make most fluoropolymer manufacturing lines unsustainable, which will lead to their shutting down in the EEA. In general, fluoropolymer manufacturing lines are specialised for this particular production process and cannot be repurposed for other non-fluorinated products. As fluoropolymers are specialty chemicals, they are typically manufactured in smaller quantities, and, therefore, the tanks and reaction vessels are generally smaller than those needed by other, more bulk, chemical processes, so it will be difficult, and may not make sense financially, to repurpose them for other products. In general, each polymerisation chemistry requires different sets of operating conditions and, consequently, a different design with regards to construction materials and the equipment overall. In addition, certain fluoropolymers, such as PTFE, are produced using highly specific manufacturing technology that are not common to other products, so it is unlikely that all the equipment can be adapted to a new use.

Furthermore, as some manufacturers specialise in fluorinated chemistry, switching their production lines to completely different chemistries is not a short- or even long-term possibility. Pivoting into completely new processes and markets is a process that typically takes many years, even decades, and it is not possible in the short timeframes available until the PFAS restriction's entry into force. The importance of the difference between types of polymerisation chemistries and their specific manufacturing processes (operating conditions, materials requirements) is fundamental to understanding that a manufacturing facility for a fluoropolymer cannot be used to manufacture another polymer.

Whether shutting down of fluoropolymer production lines will lead to wider plant closures depends on the extent to which the plants rely on fluoropolymer products. In general, fluoropolymer manufacturers expect the following impacts to their plants, depending on their individual circumstances:

- Shutting down only of specific product lines, which are used in fluoropolymer manufacturing, but no additional impacts for the rest of the plant.
- Shutting down of whole plants, as they usually rely extensively, or exclusively, on the manufacturing of fluoropolymers.

These plants are often multi-product facilities that need to have sufficient production output to support the overall operations. This is particularly important if those operations include upstream manufacturing of monomers and other raw materials used in fluoropolymer manufacturing. Such operations need to have sufficient scale of demand to continue to operate efficiently. If the demand drops significantly, as is expected in case the PFAS restriction applies as per the current proposal, upstream production lines in the EEA would also become uneconomical in most cases, leading to line and potentially plant closures.

The line and plant closures in the EEA would significantly reduce the availability of fluoropolymers in the EEA and globally, as the EEA and the UK are among the largest manufacturers globally. The EEA is also a major exporter of fluoropolymers, with approximately 24,000 tonnes exported outside EU28/EEA in 2020 and 15,000 tons imported. Shutting down of the EEA plants would mean that manufacturers will need to increase their non-EEA capacity to cover the non-EEA and derogated demand that is currently covered by the EEA plants. This cannot be completed in the short term, as expanding or building lines requires careful planning, construction time and optimisation. The global fluoropolymer industry as a whole has been working with little spare capacity, so it will be very difficult for non-EEA plants to take over additional manufacturing orders. Nevertheless, the situation for the specific fluoropolymers when examined separately may differ, with those that are primarily manufactured in the EEA (such as FKM) facing a highest risk of shortages than those whose manufacturing is spread more broadly (e.g., PTFE). It should be noted that, construction of a new fluoropolymer manufacturing line can cost tens to hundreds of million euros, depending on the size and will need several years of planning, construction, and start up.

In any case, the restriction proposal would prevent both the manufacturing and the import of fluoropolymers in the EEA, as raw materials, components or part / coating of equipment. That means that, even if manufacturing was possible in non-EEA locations in the short-term, import would still not be allowed, and the overall impacts for the EEA economy and society would in the end be the same.

A shutdown of practically all fluoropolymer manufacturing in the EEA could, therefore, impact the availability of fluoropolymers even for derogated uses in the EEA, and potentially globally.

Such a shutdown would also have serious impacts on the EU's strategic autonomy (EU-SA) objectives. The EU-SA refers to the capacity of the EU to act without excessive reliance on third countries in strategically important policy areas, such as energy supply, defence and the economy in general[15]. Many of the industry sectors relying on fluoropolymers, such as transportation and aerospace, medical devices, energy, semiconductors and electronics, etc., are considered critical for the EU and need secure supply of their raw materials and components. At the moment, EEA supply of fluoropolymers relies mostly on local manufacture. A significant increase in imports of fluoropolymers, if allowed, would jeopardise the goal of reducing foreign dependence for critical materials and components under the EU-SA concept.

In summary, the implications of implementing the PFAS restriction as it stands, without additional derogations or an exemption for use of fluoropolymers are as below:

- Shutting down of all fluoropolymer production in the EEA. This also includes upstream manufacturing and supporting operations (e.g., R&D, sales).
- Relocation of remaining production to non-EEA facilities, as the remaining output of EEA plants will not be economically sustainable.
- Relocation would require increasing capacity of existing facilities or building new ones, which would require several years to complete.
- Availability of fluoropolymers in the EEA will be very limited and may not even be sufficient for derogated uses, as non-EEA plants will not be able to cover the demand.

4.2.3 Scope of impacts for downstream users of fluoropolymers

How downstream users will react in case it is not possible to sell fluoropolymers in the EEA depends on the following factors:

- Whether a feasible non-fluoropolymer alternative is available at sufficient quantities. If companies can use an alternative for their application, they will do it. However, companies may not wish to use a material or product that has worse performance or worse durability than fluoropolymers, as this could increase the risks for human health and the environment or it could result in lower quality or unreliable products. For example, automotive or aircraft manufacturers would not accept using a part that would not perform according to their very stringent reliability and safety specifications. Similarly, food processing processes need to maintain a very high standard of cleanliness and hygiene, which may not be possible with alternative materials. As discussed in Chapter 3 of the previously submitted response by FPG, suitable alternatives may be available for a limited number of applications that do not need to meet very demanding specifications.
- Whether the fluoropolymer is used in the process or is part of the final product. In the former case, e.g., in chemical processing, the final product does not contain PFAS and thus it is possible for the entire manufacturing process to move to a non-EEA location, provided there is sufficient production capacity. In the latter case, the product containing fluoropolymers will not be available in the EEA and the user may not be able to offer it or their services to EEA customers. Such examples are sealing equipment, binders for batteries, membranes used in electrolysis and filtration equipment, etc. Note that the current restriction proposal would also impact the potential import of such products. This could have significant impacts on industrial operations in the EEA, with many high-end technology products not being able to be produced.

It should also be noted that almost all proposed derogations are time limited. Manufacturers of fluoropolymers would thus eventually have to stop any production and use of fluoropolymers in all applications in the EU would cease. Considering the lack of alternatives and the difficulty in identifying suitable

[15] European Parliament website - EU strategic autonomy 2013-2023: From concept to capacity. Available online at: https://www.europarl.europa.eu/thinktank/en/document/EPRS_BRI(2022)733589, accessed on 25 August 2023

alternatives and substituting fluoropolymers within the stipulated timeframe, most of the downstream users of fluoropolymers and fluoropolymer articles and coatings would need to cease their operations, leading to potential discontinuation of product lines.

Inability to use fluoropolymers across the range of the applications described in Section 3.3 of the previous report and summarised in Table 3.1 will have severe impacts in all those industry sectors and the EEA society and economy in general, as will be discussed in the following sections.

4.3 Impacts of a no derogation scenario

4.3.1 Indicative economic impacts

4.3.1.1 Manufacturers and importers in the EU

In 2022, the value of fluoropolymers produced and imported in the EU by FPG members participating in this study was in the range of € 1.0 – 3.0 billion, as shown in Table 4.3. The overall trend for fluoropolymer demand in the short-term is expected to be a slow growth in most markets in a baseline scenario. However, the expected pressure from customers to move to non-PFAS alternatives could restrain that growth if alternatives are developed and tested successfully. Nevertheless, it is expected that this organic substitution of fluoropolymers in some less demanding applications will not have a significant impact on overall demand and the value of fluoropolymers from FPG members would remain in that range.

If the PFAS restriction is adopted as currently proposed, the small share of fluoropolymers that will be covered by the proposed time-limited derogations will not be sufficient to support the manufacturing activities in the EU and it is possible that the FPG members' plants will be forced to shut down their fluoropolymer operations. Therefore, the whole value of € 1.0 – 3.0 billion per year will be lost.

It is unlikely that this will be replaced by value generated by alternative materials or processes, considering the overall difficulty in identifying suitable alternatives to fluoropolymers, as presented for the different market sectors in Section 3.3 of the previous FPG response. This could change slowly over time but cannot be predicted.

The value of €1.0 – 3.0 billion per year refers to the estimated 2022 revenue of the FPG members that participated in the study. Projecting to 2025, using the expected growth rates for each use, as presented in Table 4.3**,** would give a value of the fluoropolymers manufactured and sold in the EEA in the range of €1.2 – 3.5 billion. Maintaining the same annual growth rate until 2030 would give a Net Present Value of €6.2 - 18 billion for the 2025 – 2030 period, discounted to 2025 prices.

4.3.1.2 Downstream user sectors

The value of the fluoropolymer industry by itself can be considered relatively modest when compared to the total output of the EU economy. However, as discussed in Section 3.3 of the previous report, fluoropolymers are used in a broad range of applications, supporting a diverse group of critical applications, such as vehicle safety, semiconductor manufacturing, drinking water and wastewater treatment and various energy-related applications. The value of these markets is many times higher than that of the fluoropolymers. Table 4.5 summarises the combined value of those EU markets that rely extensively on fluoropolymers, based predominantly on publicly available information.

It should be noted that the information in the following table is for illustrative purposes and is intended to give an indication of the magnitude of the importance of fluoropolymers in the whole EU economy. The numbers are mainly based on assumptions, described in the "Discussion" column of Table 4.5, as more specific information was not available to FPG members. Depending on the available information, different approaches were followed for each market sector. It is understood that the relevant industry associations (e.g., Euratex for textiles, CEFIC for chemical processing, ACEA for automotive, ESIA for semiconductors) will submit more specific information to the open public consultation on use and application information, as well as the impacts in their sectors.

Table 4.5 Size of markets relying on fluoropolymers

Sector of use	Current market value in € (where available)	Source	Assumed value of market relying on fluoropolymers	Discussion
Transportation and aerospace (excluding lubricants)	Automotive: 390 billion manufactured in 2021 1.12 trillion in sales in 2019 according to Eurostat Aviation: 241 billion direct turnover (578 billion including indirect and induced)	[1] [2] [3] [4]	Automotive: €195-390 billion Aviation: €60 – 120 billion	12.1 million cars were manufactured in the EU in 2021 (and a total of 13.1 million vehicles, including vans, trucks and buses). The average car price in Europe in 2020 was approximately €32,000, approximately 15% higher than in 2015. This gives an average value of automotive output at approximately € 390 billion. Fluoropolymers are essential components that ensure safety and effective operation of the vehicles and they are highly durable even at extreme operating conditions. It can thus be assumed that up to 100% of the value of the automotive sector produced in the EU, including a €101.9 billion trade surplus, is relevant to fluoropolymer use. The aviation industry revenue includes production of civil aircraft, aircraft engines, parts and components. The total market value accounts for revenue for civil aeronautics and civil space applications, according to the ASD economic impact brochure. Not all of the manufactured parts and components rely on or use fluoropolymers, but there are several critical applications which could impact the safety or performance of parts or even the whole aircraft. Without more detailed information on the breakdown of the aviation market, only assumptions can be made. For the purposes of this exercise, a factor of 25-50% is assumed.
Industrial applications (chemical industry)	€ 593.7 billion in 2021 of which: € 153.4 billion petrochemicals € 26.9 billion inorganic € 16.1 billion industrial gases € 29.3 billion fertiliser and N-compounds € 109.2 billion primary plastics €4.6 billion synthetic rubber € 7.8 billion man-made fibres	[5]	€ 65.8 – 193.5 billion in 2021	Fluoropolymers are used in sealing equipment, pipe and vessel linings, coatings, as well as filters and other equipment in chemical manufacturing processes, especially where extreme / harsh conditions are expected (very high or cryogenic temperatures, high pressures or vacuum, corrosive or very reactive chemicals, mechanical stress, etc.). In addition, seals are also important in containing hazardous substances and preventing leaks and unwanted release in the workplace and to the environment. The actual share of chemical processes using fluoropolymers cannot be known with precision. It is understood that petrochemicals and the inorganic chemicals industries (particularly the chloralkali industry) rely heavily on fluoropolymers, with the other sub-groups using fluoropolymers to a smaller, but critical, degree. It should be noted that many of the chemical products from these processes are used in other processes downstream or in different industry sectors (e.g.,

Sector of use	Current market value in € (where available)	Source	Assumed value of market relying on fluoropolymers	Discussion
	€ 10.5 billion dyes and pigments € 13.5 billion agro-chemicals € 45.5 billion paints, varnishes & coatings € 96.5 billion other chemicals € 80.3 billion consumer chemicals			in manufacturing as processing aids or components). As such, they support a larger market share than that calculated here.
Construction materials and products	€ 13 trillion GDP	[6]	Expected to be in the range of tens of billions	Fluoropolymers are used in various construction applications, offering protection against the elements and excellent overall durability over the building's lifetime. However, their value is mainly measured against the reduced need for maintenance and limited loss of performance over time when compared with alternative materials. As such, it is not possible to calculate the exact share of the overall construction industry relying on fluoropolymers, but there is wide use for certain applications, such as coatings for roofs and facades, bridge and wind turbine base bearings, greenhouse films, and PTFE thread sealings for piping.
Energy applications, including batteries and hydrogen	Batteries: 3-14 billion in 2025 (projected) Hydrogen: 21 billion for fuel cells by 2030 18.75 billion in electrolysers by 2030	[7] [8]	Batteries: 1.5-14 billion in 2025 (projected) Hydrogen: up to € 39.8 billion by 2030	Fluoropolymers are essential for Li-ion batteries, as alternative binders are not suitable and it could take several years to identify and implement a substitute. The EU market can increase from €340 million in 2016 to €3-14 billion in 2025 and fourfold that by 2030, stimulated primarily by the increased demand for electric vehicles and for energy storage. All hydrogen-related projects, both for electrolyser applications and for fuel cells (for vehicles or other end uses), rely on the use of fluorinated ionomers and PTFE. As alternatives are not suitable (Section 3.3.4 of the previous report), it can be concluded that up to 100% of the value of hydrogen applications relies on use of fluoropolymers.
Petroleum and mining	29.95 billion in 2019 for O&G extraction in EU 55.2 billion in 2019 in Norway	[9]	€ 42.6 – 85.2 billion in 2019	As discussed in Section 3.3.5 of the previous report, fluoropolymers are essential in a broad range of applications in the oil and gas extraction sector, as well as downstream, in transport and refining of petroleum products. Considering the lack of suitable alternatives and the difficulty in substitution it can be assumed that up to 100% of the value of oil and gas extraction in the EEA may rely on the use of fluoropolymers.

Sector of use	Current market value in € (where available)	Source	Assumed value of market relying on fluoropolymers	Discussion
Food contact materials and packaging (excl. lubricants)	Industrial: 1.1 trillion (added value of 222 billion)	[10]	Consumer: € 2 billion Industrial: € 550 billion	The whole food and feed processing industry could be relying on the use of fluoropolymers. As discussed in Section 3.3.6 of the previous report, there are no suitable alternatives for such applications, as the most likely alternatives are less durable and would need replacement more often. Nevertheless, it is understood that, in some lower-end applications, fluoropolymers may be possible to substitute with lower performing materials. Therefore, as a conservative assumption, it will be assumed that 50% of the food and feed industry output will be relevant to fluoropolymer use. Annex E to the restriction proposal also refers to a value of €2 billion for consumer products, based on PlasticsEurope data from 2018. It can be assumed that this value has remained stable until now.
Electronics and semiconductors	Semiconductors: 53.8 billion in EU Electronics: 88.7 billion in 2022 (projected)	[11] [12]	€ 26.9-53.8 billion in 2021 – to increase significantly by 2030 € 8.7-26.2 billion in 2022 (projected)	EU semiconductor manufacturing relies completely on PFAS in general and fluoropolymers specifically. Filters and sealing for manufacturing equipment are essential for the high-cleanliness semiconductor fabrication environments. Therefore, it is assumed that up to 100% of the value of the semiconductor industry is relevant to fluoropolymer use. The knock-on benefits from the use of semiconductors downstream can be orders of magnitude higher, considering they are used in practically all information and telecommunications equipment, as well as consumer and industrial electronics. Semiconductors are also expected to be increasingly used in automotive electronics, with more electronics and automated control in newer vehicle models. Fluoropolymer use in electronic equipment also includes coatings, sealing and cable / wire jacketing, particularly for equipment that is expected to operate in harsh environments, with extreme temperatures, aggressive chemicals and constant mechanical stress. Industrial electronics manufactured in the EU, with applications in manufacturing, testing and measuring, transportation, power applications, as well as home and building automation, had a value of 74.3 billion in 2016, with a CAGR of 4% since 2010. Using a smaller, 3% annual growth rate, to account for the Covid-19 pandemic, the market could be worth close to € 89 billion in 2022. Fluoropolymers may be used in all these applications, but they appear to be extremely important for factory applications and testing (as many DU have mentioned the importance of using FP-jacketed cable in sensors and

Sector of use	Current market value in € (where available)	Source	Assumed value of market relying on fluoropolymers	Discussion
				metering devices), as well as transportation and power. For the purposes of this exercise, a 25-50% factor will be assumed for the factory applications and a smaller, 5-25% for the rest.
Water and wastewater treatment	€640 million for ultrafiltration membrane market	[13]	€470 million for ultrafiltration membranes Much higher value for projects using ultrafiltration membranes	The most obvious application of fluoropolymers in water and wastewater treatment is in filtering membranes, used to remove contaminants from the water. There are also other applications, such as piping, sensors and pipe sealing. According to market research, the value of the ultrafiltration membranes global market was approximately $4.2 billion in 2021 and was expected to grow at a CAGR of 5.9% to $5.8 billion by 2026. Approximately 18% of the global volume was sold in Europe, which gives an estimate of approximately $750 million (€640 million). The same report estimates that approximately 95% of the membranes sold, by volume, were polymeric, and the remaining were ceramic. Approximately 77% of the polymeric membranes were fluoropolymers, i.e., PVDF. This would give a market value for ultrafiltration membranes of approximately €470 million in 2021, but the actual value of the projects supported by these components is much higher.
Lubricants			Covered by other sectors of use	Fluoropolymer lubricants have a broad range of applications, as discussed in Section 3.3.9 of the previous report. Indicative sectors of application of PFPE- and PTFE-based lubricants include automotive, aerospace, industrial machinery, construction, etc. As such, all connected market value is covered by the discussion in the respective sectors and mentioning it again in lubricants could lead to double counting.
Medical devices	€150 billion, of which € 14 billion for IVD	[14]	Expected to be in the range of tens of billions. More specific information may be available at MedTech Europe's response to the open public consultation. (Volume 33; comment #6208)	Fluoropolymers are mainly used as coatings in medical devices, but the share of impacted medical devices is unclear, especially considering the very large number of different medical devices and IVDs (more than 500,000 different products). They are used in a broad range of different devices, such as invasive devices (stents, catheters, sutures, hernia meshes), in components for treatment of serious diseases, in ophthalmic products, as well as in IVD instruments[16].

[16] MedTech Europe PFAS briefing 27 February 2023. Available online at: https://www.eflm.eu/upload/docs/230227_MTE_PFAS_Briefing_DRAFT_V3.pdf, accessed on 24 August 2023

Sector of use	Current market value in € (where available)	Source	Assumed value of market relying on fluoropolymers	Discussion
Cosmetics and personal care	88 billion (retail value) > 29 billion added value	[15] [16]	€ 410 million (retail value) € 130 million (value added)	According to Annex A to the restriction proposal, the share of cosmetic products containing PFAS was approx. 1.4% in 2019. This refers to number of products, so the actual volumes and sales will likely be different, but not significantly so. It is understood that not all of these products contain fluoropolymers, though PTFE is among the most frequently ingredients mentioned. Without more detailed information available, it can be assumed that fluoropolymers account for one third of these uses.
TULAC (Textiles, upholstery, leather, apparel and carpets)	147 billion produced in EU-27	[17]	€ 20.4 billion in 2021	According to EURATEX, industrial and technical textiles account for 17% and man-made fibres for 5% of total EU production. Home textiles account for 14% and fabrics for 15%. Not all of this production uses fluoropolymers, but, considering the importance of fluoropolymers for technical and industrial textiles, it can be assumed that more than 50% of these rely on fluoropolymers. For the other categories, a more modest share of 5-25% is assumed.
Metal plating and manufacturing of metal products	Not available		Not available	The dossier submitters estimated a usage of 900 tpa of fluoropolymers in manufacturing of metal products. FPG members have declared sales volumes of 20-200 tpa, but this value may be larger, as distributors may be selling to various markets, which behaviour is not captured by the FPG members' sales departments.
Ski treatment (waxes)	51 million	[18]	0	Fluoropolymers are used in a small share of ski treatment waxes, but the majority of PFAS used therein are perfluoroalkanes or semi-fluorinated alkanes. As such, and considering that neither FPG members nor downstream users of fluoropolymers mentioned this application in their operations, the share will be assumed to be zero.
Consumer mixtures	10-30 million for guitar strings Unclear for other applications	[18]	€ 10 – 30 million	The tonnage of fluoropolymers intended for consumer mixtures is very low and it is expected to be phased out in the near future. Currently, fluoropolymers are used mainly in waxes and polishes. The overall value of the remaining relevant markets cannot be estimated from the available information. Therefore, only the conservative estimation of the guitar string market segment is considered.
Total			**More than € 900 – 1,400 billion (rounded)**	The sum value to the left does not include the potential impact for hydrogen technologies, which even though they have a relatively small value currently,

Sector of use	Current market value in € (where available)	Source	Assumed value of market relying on fluoropolymers	Discussion
				are expected to expand significantly in the near future and reach approximately € 40 billion by 2030 and even more in the long-term. It should also be noted again that this value holds significant uncertainty and is used to illustrate the value in the downstream market sectors that potentially rely on fluoropolymers. Compared to the value of the fluoropolymers themselves it is two to three orders of magnitude larger. Nevertheless, it must also be noted that this should not be interpreted as potential economic impacts in case fluoropolymers are not exempt from the PFAS restriction. It can be used, however, as an indication of the size of the EU economy connected to the use of fluoropolymers.

Note:
Where more precise information was not available, three main ranges were used to estimate the connection of a certain sector's output to fluoropolymers:

- 50-100% for highly reliable data on applications
- 25-50% for somewhat reliable data on applications
- 5-25% for low level of reliability of data on applications

The justification for the level of reliance is presented in the relevant cell in the "Discussion" column
List of sources:
[1]: https://www.statista.com/statistics/425095/eu-car-sales-average-prices-in-by-country/
[2]: https://asd-europe.paddlecms.net/sites/default/files/2022-11/EIS-brochure%20for%20web_pages.pdf
[3]: https://ec.europa.eu/eurostat/databrowser/view/SBS_NA_IND_R2__custom_6924836/default/table?lang=en
[4]: https://www.acea.auto/fact/facts-about-the-automobile-industry/
[5]: https://cefic.org/a-pillar-of-the-european-economy/facts-and-figures-of-the-european-chemical-industry/
[6]: https://ec.europa.eu/docsroom/documents/15866/attachments/1/translations
[7]: https://euratex.eu/wp-content/uploads/EURATEX_FactsKey_Figures_2022rev-1.pdf
[8]: https://op.europa.eu/en/publication-detail/-/publication/530105f4-493d-11ea-b81b-01aa75ed71a1/language-en
[9] https://ec.europa.eu/eurostat/databrowser/view/SBS_NA_IND_R2__custom_6924836/default/table?lang=en
[10]: Amec Foster Wheeler, 2017 (Annex E)
[11]: Submission 4449 to the OPC
[12]: https://visitors-centre.jrc.ec.europa.eu/en/media/infographics/lithium-ion-batteries-scenarios-cost-and-market-growth
[13]: https://www.bccresearch.com/market-research/membrane-and-separation-technology/ultrafiltration-membranes-techs-markets-report.html
[14]: https://www.medtecheurope.org/about-the-industry/facts-figures/
[15]: https://cosmeticseurope.eu/cosmetics-industry/
[16]: Annex A to restriction proposal (Section A.3.7)
[17]: https://hydrogeneurope.eu/wp-content/uploads/2023/02/Hydrogen-Europe-position-paper-on-PFAS-ban_v12_FINAL.pdf
[18]: Annex E to restriction proposal – consultation comments (Section E.2.5.4)
[18]: Annex E to restriction proposal (Section E.2.7.4 – Table E.82)

Table 4.5 highlights the importance of fluoropolymers across a broad range of industry sectors in the EU. This study estimates that fluoropolymers contributed to downstream products and operations worth between approximately €700 and €1,400 billion in 2022. Considering the expected growth in many of these sectors in the coming years as a result of market shift and the EU's policies, this number could be much higher by 2030 and even higher by 2040 and 2050. Also, as mentioned above, this is just an indicative value based on a number of assumptions.

If the same approach as the one for the fluoropolymer market (Section 4.3.1.1) is followed, the value of these markets in 2025 can be calculated at €1.0 – 1.5 trillion, and an overall NPV for the 2026 – 2030 period would be €4.8 – 7.2 trillion. Nevertheless, it must again be noted that these are illustrative calculations to highlight the importance of fluoropolymers to downstream markets and was based on very high level, and in places incomplete, data. Therefore, it should be considered and quoted with caution.

To these values, one should also add the importance of fluoropolymers in enabling tens if not hundreds of billions' worth of investments in innovative technologies and projects that contribute to the EU's climate change and decarbonisation goals for 2030 and 2050. Such technologies and projects include (green) hydrogen generation, storage and transport projects, batteries for energy storage and electric vehicles, as well as expansion of semiconductor fabrication capacity.

4.3.2 Societal benefits from applications of fluoropolymers

As shown in Section 3.3 of the previous report and summarised in Table 3.1, the range of fluoropolymer applications is very broad and spans the whole EU industry landscape. In most of these applications, substitution potential is low, due to the very high technical specifications and critical requirements of the use, which can only be met by fluoropolymers, and, in the event of a potential alternative being identified, the long substitution timelines often required by each industry sector's validation and qualification procedures. The lack of alternatives that can meet the performance and durability requirements in those applications underlines the importance of fluoropolymers for the continued offering of the relevant products and services that are critical for the EEA's industry, economy and society.

In general, fluoropolymers are usually selected as an option after non-fluorinated alternatives have been assessed and rejected for various reasons. As can be seen from the discussion on fluoropolymer applications, fluoropolymers are used where a combination of resistances to various harsh conditions over long periods of time is required for the product or process to meet critical performance specifications. Considering the fluoropolymers' comparatively higher unit costs, if more economically favourable alternatives were available, this would have been a driver for their substitution. As the potential alternatives have lower performance, increased weight and / or worse durability than fluoropolymers, using them may not be an option, especially in critical safety applications such as semiconductors and electronics, transportation, chemical and petroleum industries and food processing, as well as medical devices.

Table 4.6 provides an overview of the benefits to the EU from the use of fluoropolymers in the different use sectors.

Table 4.6 Summary of societal benefits from fluoropolymer applications

Use sector	Indicative uses	Benefits from the continued use of fluoropolymers
Transport, including automotive and aerospace	Fuel tubing and hose, engine oil and drivetrain seals (O-rings, gaskets), O-rings, seals, gaskets, ice-phobic coatings on helicopter rotor blades, window shades Exhaust gas pipes. Fuel cell membranes Oxygen, NO_x sensors, emission control systems. Pedal, battery, oil, radar, rain-light sensors Transmissions seals, thermal management systems Transfer or compression moulded automotive fuel Wires and cables Signal, control and power wires and cables insulated with fluoropolymers in military and civil aviation. Foams in aircraft insulation Electroluminescent lamps	Most land vehicles and aircraft could not be manufactured, sold or even repaired in the EU without the use of fluoropolymers. Fluoropolymers are used in hundreds of individual components, offering excellent durability under harsh operating conditions and ensuring safe and efficient operation of the vehicle. Cars and aircraft are complex vehicles with thousands of individual parts and components, all of which must meet very strict performance and safety specifications. This performance must be maintained over decades of operating life of the vehicle. The current car and aircraft designs are offering the highest possible performance and safety with the help of fluoropolymers in most of their components. Fluoropolymers have been used in vehicles and aircraft for many decades and are part of their design. To maintain the performance and safety of a vehicle or craft throughout their long service life, OEMs and OVMs must supply spare parts for several years after the end of serial production. Depending on the contract, this can be as long as 10 or 15 years, and maybe even longer for aircraft, which have lifetimes of several decades. If fluoropolymers cannot be used in these spare parts anymore, it can mean that cars may not be able to be serviced properly or use lower performing unauthorised spare parts. Aircraft, which are required to use only authorised spare parts, could not be serviced or repaired at all until non-fluoropolymer parts could be designed and approved, after they run out of the supply of existing fluoropolymer spare parts. This process takes several years after validation of the alternative. In addition, airline operators are obliged to ensure the airworthiness of their fleet before every flight, as per Regulation (EU) 2018/1139 on common rules in the field of civil aviation […][17]. If it is not possible to have (or easily procure) the necessary (fluoropolymer) spare parts or subsystems to maintain or repair the aircraft at every airport, guaranteeing airworthiness may not be possible. Carrying out maintenance operations only in non-EEA locations carries a huge risk and may not even be possible for the majority of the smaller, regional airlines. Furthermore, alternative materials have lower performance and higher weight, which would lead to negative effects on safety, fuel consumption and fuel efficiency in vehicles. As a result, vehicles may break down more often (including higher risk for aircraft part failures) or be abandoned for newer ones, leading to greater waste generation and higher raw material and energy consumption, and, therefore, a much worse environmental footprint.

[17] Regulation (EU) 2018/1139 of the European Parliament and of the Council of 4 July 2018 on common rules in the field of civil aviation and establishing a European Union Aviation Safety Agency, and amending Regulations (EC) No 2111/2005, (EC) No 1008/2008, (EU) No 996/2010, (EU) No 376/2014 and Directives 2014/30/EU and 2014/53/EU of the European Parliament and of the Council, and repealing Regulations (EC) No 552/2004 and (EC) No 216/2008 of the European Parliament and of the Council and Council Regulation (EEC) No 3922/91 (Text with EEA relevance.). Available online at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32018R1139, accessed on 25 August 2023

Use sector	Indicative uses	Benefits from the continued use of fluoropolymers
Chemical processing	Fluid handling systems, Pipes (solid pipes and pipe linings), flue duct expansion joints. Seals, gaskets, valves, fittings, linings, filters, O-rings. PTFE-thread sealing tape. Tanks, lining of reaction vessels. Ion-exchange membranes (e.g., for chloralkali production). Wire and cable coatings for sensors, flowmeter tubes, and other electrical and electronic sensing and control equipment.	The EU is among the largest chemical manufacturing regions in the world, with a total output of almost € 600 billion (corresponding to a 14.7% global market share) and a trade surplus of over € 36 billion in 2021. Fluoropolymers ensure the safe operation of equipment which needs to work continuously under extremely harsh and dangerous conditions with practically no margin for errors. Many key refining and chemical manufacturing processes use fluoropolymers to ensure high efficiency and minimal leakages and loss of materials. High temperature processes, such as those carried out in oil refineries and petrochemical plants, and processes using corrosive agents (acids, bases) benefit from the use of highly durable sealing and lining fluoropolymer components, with longer service life for the equipment and significantly reduced need for maintenance or replacement due to breakdowns. Certain processes also need to be carried out at high temperatures or pressures. In addition, essentially the whole chloralkali industry needs fluoropolymers for their electrolytic cells. Without fluoropolymers, there could be a significant shortage of critical building blocks in the chemical industry, i.e., hydrochloric acid and sodium hydroxide. It must also be noted that chlorine is the chemical most commonly used to disinfect drinking water. Here, it should be noted that the chemicals processing industry is strongly interconnected, with the products from one process used as feedstock in several downstream ones. Therefore, use of fluoropolymers in an upstream process, e.g., in a refinery or a petrochemical plant, supports multiple downstream processes not just in the chemical industry but also in the manufacturing sector. Therefore, the implementation of fluoropolymer components, linings and coatings is essential for the uninterrupted and efficient operation of critical chemical processes in the EU.
Construction	Wire and cable insulation, plenum cable insulation, Architectural protective and decorative coatings (e.g., on bridges), laminates, resistant paints, anti-graffiti and antifouling coatings, surface treatment in natural stone, metal, glass, plastic Bridge and offshore pad bearings Greenhouse films PTFE-thread seal tapes for pipes	Fluoropolymers have several applications in construction, especially as protective materials and coatings, protecting exposed surfaces from the elements and waterproofing structures. They are extremely durable and very light, reducing the load on the construction and protecting it from wear. Fluoropolymers are also flame resistant or completely non-flammable, and can thus reduce the risk of fire, especially in electrical installations. In larger constructions, such as bridges and offshore towers, use of lightweight and very low friction PTFE bearings ensures minimal wear and maintenance, and thus structural integrity throughout their very long lives. Also, use of PTFE-thread tapes, as well as fluoropolymer seals in gas and fuel installations in houses, prevents leakages and potential explosions or other accidents.

Use sector	Indicative uses	Benefits from the continued use of fluoropolymers
		In summary, fluoropolymers offer efficient and economic solutions for safer buildings and constructions with lower need for maintenance and repair.
Energy, batteries and hydrogen	Solar panel coatings, O-rings, seals, gaskets, proton exchange membranes in fuel cells, in alkaline electrolysers and for hydrogen production via electrolysis, binder materials in the electrodes, both anode and cathode, and as a component of the gas diffusion layers (GDLs). Infrastructure for transport and storage of hydrogen (lining materials, seals etc.), seals in liquid organic hydrogen carrier technologies. Potentially in turbines in flanged connections in order to mitigate leakages, in power generation using H_2. Binders in electrodes of batteries, separator coatings, additives in the electrolyte, gaskets/seals, pipes, valves and sealings in the battery itself, manufacturing of positive electrodes for Li-ion cells Solar panel and wind turbine blade coatings.	Fluoropolymers are a key enabler for promoting sustainable energy generation, contributing to the EU's climate change and decarbonisation goals for 2030 and 2050. They are key components in established and emerging technologies, and help develop the new energy generation, storage and transport / transmission in the EU in the short- and long-term. Without polymers, development and adoption of hydrogen generation, storage and transport technologies in the EU will be severely constrained, as they are essential components of electrolysers and electrodes. In addition, they can be used as high-performance seals and linings in hydrogen transport and storage equipment. Hydrogen is a very elusive, and highly flammable gas, so containing any potential leaks is essential for the safety of personnel and equipment. Use of batteries for EV and storage of energy from renewable energy sources (RES), which do not always produce during peak electricity demand, is expected to rise sharply in the EU until 2030 and beyond. Fluoropolymers are also a key material for batteries, allowing for long lifetimes without need for replacement, thus also contributing to reduced (critical) raw material usage. Established RES also use fluoropolymers as protective coatings to ensure low wear and reduced need for maintenance, as well as for lubrication. For example, PFPE can be used as lubricant in difficult to reach wind turbines, as it requires less frequent maintenance. Even conventional power generation facilities, including nuclear use fluoropolymer seals and wire jacketing to mitigate leakages and increase efficiency in their operations. In summary, fluoropolymers are essential for the present and the future of energy generation, storage and transmission in the EU. Without these materials, the overall carbon footprint of the EU power generation would be much higher and the EU's climate change and decarbonisation goals would be jeopardised.
Petroleum and mining	Chemical resistant components (e.g., seals) and coatings for extraction, transport and processing of petroleum and ores. Wire and cable insulation and covering Coating for sensors	The proposed broad derogation for all uses of fluoropolymers in petroleum and mining applications highlights the importance of the materials for the sector. Fluoropolymers ensure the safe operation of equipment which needs to work continuously under extremely harsh and dangerous conditions with practically no margin for errors. However, the limited duration of the derogation puts the long-term safety and performance of equipment in these applications at risk, as identification of technically feasible alternatives even in the long derogation period proposed is very uncertain.

Use sector	Indicative uses	Benefits from the continued use of fluoropolymers
		Fluoropolymers are thus essential for a foundational industry sector providing the EU with necessary raw materials that strengthen its independence for supply of critical raw materials and oil and gas.
Food contact materials and packaging	Industrial, commercial and consumer cookware and bakeware Water and oil-repellent coating on paper products and packaging (cans, bags, etc.) Conveyor belts for cooking and drying foodstuff Extrusion and processing aids for plastic film production Process lubricants	As mentioned in Annex E to the PFAS restriction proposal (Section E.2.3.4.3), fluoropolymers are widely used in the food and feed processing industry, with practically all almost 300,000 companies (of which 99% are SMEs) using fluoropolymers at some stage in their processing facilities, as coatings, seals or food handling equipment. Fluoropolymers minimise the risk of contamination and enable easy cleaning of processing lines, vessels and piping. It can be therefore said that without fluoropolymers, the production output and the quality, if not the safety, of food and feed produced in the EU would be at risk.
Electronics and semiconductors	Components of electronic devices (e.g., Hard disk drives), Semiconductor manufacturing (e.g., HEPA filters, wet processing equipment components) O-rings, seals, gaskets, parts and tubing used in the semiconductor processing industry, Welding and soldering agent, Insulation in wires and cables, Coatings, batteries and smart devices Powder coating for phone and tablet screens. Anti-reflective coatings for semiconductors Sensor applications (industrial, automotive, measuring and analytical)	Digitalisation is among the main goals of the EU, and will contribute to strengthening the EU industry, power generation and transmission, and towards the EU's climate goals, among other benefits. Technology has also been becoming increasingly more elaborate and "smart" electrical equipment is available in more and more aspects of everyday life, but also in commercial and industrial environments. All these are enabled by the use of semiconductor chips, which are becoming increasingly sophisticated and miniaturised. Semiconductors have been among the largest drivers to increase productivity and quality of products in the EU. The EU has recognised their importance and plans to strengthen its position in the global market and increase its technological independence, with the European Chip Act, which was approved by the EU Parliament in July 2023. Manufacturing of semiconductors would not be possible without the use of fluoropolymers, which are used in all phases of fabrication and are also used in chip packaging. Fluoropolymers and semiconductor chips are also used directly on the electrical and electronic equipment practically across all sectors of the economy and all levels of society, increasing durability of sensitive equipment and prolonging their lifetime. They are, therefore, a significant enabler of lower waste generation and critical raw material usage in the EEE sector, as they contribute to more resilient equipment.
Water and wastewater treatment	Hollow fibre micro- and ultra-filtration water & wastewater treatment membranes Water piping	Fluoropolymer (PVDF) membranes have been used for decades in a broad range of water treatment applications in the EU, including wastewater and drinking water applications. Their durability against aggressive contaminants in the treated water make them the material of choice in demanding applications. Drinking water treatment is subject to very high quality and cleanliness specifications in terms of e.g., organic content, metals content, removal of pathogens, etc. Municipal water plants vary in size, depending

Use sector	Indicative uses	Benefits from the continued use of fluoropolymers
		on the size of the community they serve, with the larger ones serving more than a million people in major EU cities and agglomerations. These treatment plants are designed to operate for decades, during which time they will undergo changes in capacity, treatment methods and efficiency targets arising from new regulations. Similarly, wastewater treatment plants are designed and built on limited space, which needs to take into consideration potential expansion of capacity. In both cases, fluoropolymer membranes are more efficient and can offer better removal of contaminants and pathogens than alternatives, at a smaller volume and with longer lifetime. Therefore, they contribute to both reduced construction and operating costs, as the facilities can have a smaller footprint and require less maintenance and replacement. The amount of fluoropolymer membranes sold in Europe in 2021 for potable water, wastewater and industrial water treatment was approximately 7.9 million m^2, while the surface area of fluoropolymer membranes currently in use in Europe is estimated at 10.2 million m^2, which is sufficient to service the equivalent of 159 million households (assuming a flux of 65 litres per m^2 per hour and typical usage of 100 litres per day per household.) This number is expected to increase significantly in the near and mid-term, as the ultrafiltration market is expected to exhibit strong growth with a CAGR of approximately 5.9%[18]. Fluoropolymers are also important in water piping, where their high durability and very good fitting prevents leakages and minimises the need for repair or replacement, thus reducing costs for both consumers and the operators / municipalities. In addition, they preserve water, which is an increasingly important resource in the EU, especially considering the increasing impacts of climate change, with warmer temperatures and more severe droughts.
Lubricants	High performance lubricants (stable and inert) for applications in the aerospace, military, automotive, electronics, semiconductor, textile, chemical, paper, plastic and nuclear industries. High performance lubricants for engines and machinery.	Fluoropolymer lubricants (mainly PTFE and PFPE) are used across the industry spectrum in the EU, maintaining high performing equipment such as cars and aircraft, as well as vacuum pumps in the chemical, food processing and manufacturing industries, among others. They are among the best performing lubricants in applications where durability and stability at a broad range of extreme conditions (temperature, pressure, corrosive agents) are required, and, in some cases, they are the only option available to meet the strict industry and regulatory requirements.

[18] BCC Research website – Ultrafiltration membranes: Technologies and global markets. Available online at: https://www.bccresearch.com/market-research/membrane-and-separation-technology/ultrafiltration-membranes-techs-markets-report.html, accessed on 25 August 2023

Use sector	Indicative uses	Benefits from the continued use of fluoropolymers
	Lubrication for vacuum pumps, high-pressure oxygen equipment. Non-stick coatings as dry film lubricants in baked goods production, food processing, automotive and transportation, high-temperature kitchen equipment, medical equipment.	In addition, their durability makes them excellent for use in remote locations, such as in wind turbines or photovoltaic installations, leading to lower maintenance and repair needs. Use of lower performing lubricants could lead to worse performance of equipment and vehicles and could lead to higher rates of breakdowns and need for maintenance and replacement.
Medical devices and pharmaceuticals	Biomedical devices Other medical devices, e.g., catheters, stents, heart patches, sutures, seals, lubricants, filters or surface treatment Coating in primary packaging components, coating for metered dose inhalers Analytical equipment and laboratory applications.	Use of fluoropolymers in the medical device and pharmaceutical sectors is very extensive and ranges from coatings on invasive and non-invasive medical devices and packaging, to sealing and wires used in analytical and IVD instruments, to filters and other components in manufacturing operations where high cleanliness conditions are required. The medical device industry in the EU is among the most innovative ones worldwide and offers patients globally a range of products that enable advanced treatment for acute and chronic health conditions. Their use is becoming increasingly important, especially considering the aging of the EU population and the increased need for operations, invasive or not. In addition, the analytical equipment used in diagnosis and monitoring of patients' health uses fluoropolymer coatings and components to perform its operations with precision. The IVD industry has developed very sophisticated and accurate solutions that allow doctors to make quick and informed decisions for each patient. Apart from the applications explicitly mentioned in the proposed and considered derogations, medical equipment using fluoropolymers include endoscopy and other monitoring / sensor equipment, which need miniaturised wires with fluoropolymer jackets. Overall, use of fluoropolymers in the pharmaceutical and medical device industry enables the development and application of innovative, advanced diagnostic, treatment and monitoring methods, that improve the quality of medical services offered to patients in the EU and worldwide.
TULAC	Waterproof and stain repellent clothing Chemical resistant PPE, fabrics, and high-performance textiles Membranes used as filtering media in applications with very low contamination tolerance (e.g., semi-conductors, pharmaceuticals, medical devices, chemical processing)	Benefits from the use of fluoropolymers in the textile and clothing sector can be seen in two aspects. Firstly, professional textiles, not just PPE, that require water and / or oil repellence are more durable and efficient, offering greater protection over their expected long service life. With higher durability, they contribute to lower generation of waste and material use. Secondly, technical and industrial fabrics are essential, e.g., as filters or separation media, for applications with low contamination tolerance and where cleanliness of the fabrication / manufacturing environment are of utmost importance. Fluoropolymer filters are used across several key EU industry sectors, such as

Use sector	Indicative uses	Benefits from the continued use of fluoropolymers
	Coated fabrics for architectural applications, tents and furniture	semiconductors, (bio)pharmaceuticals, medical devices (including IVDs) and some fine chemical manufacturing processes.
Metal plating and manufacturing of metal products	Noise suppression, anti-foam agent Electrical insulation and sealing in metal heating processes. Noise reduction and as dry bearings in metal product manufacturing processes.	

Overall, the benefits from the use of fluoropolymers to the EU society can be summarised in the following points:

- They enable the development and availability of innovative technologies in all sectors of the economy, such as semiconductors used in an increasing range of equipment, including (electric) vehicles, technologies for green energy generation, transport and storage, and
- They increase safety in equipment and products used by industry, professionals and consumers, such as vehicles, aircraft, gas and electricity installations in buildings, and medical equipment. This safety is relevant to both human health and the environment as the equipment is critical in preventing emissions of hazardous chemicals or of chemicals that could cause potentially catastrophic product failure.
- They provide extremely durable components and coatings used in a range of extreme, harsh conditions, minimising the risk of breakdowns and the need for replacement, thus contributing to lower waste generation and lower consumption of often-critical raw materials.

4.3.3 Wider EU societal impacts

As shown in Table 4.6, fluoropolymer applications are central to the realisation of major goals set by EU strategies, such as the European Green Deal, the Critical Raw Materials Act and the EU's Digital Strategy. The industries, sectors and technologies that rely on fluoropolymers are among the key enablers of the EU's strategic goals.

The following sections provide a brief overview of the importance of fluoropolymers in some of the EU's core environmental and technology strategies.

4.3.3.1 EU Green Deal

The EU Green Deal was first presented in December 2019 and since then has driven the development of a comprehensive set of strategies for all environmental aspects and economic sectors. Its strategies aim at pushing the EU into a more sustainable and greener future, without impairing the competitiveness and innovation of the European economy.

The Green Deal aims to improve the well-being and health of citizens and future generations by providing[19]:

- fresh air, clean water, healthy soil and biodiversity
- renovated, energy efficient buildings
- healthy and affordable food
- more public transport
- cleaner energy and cutting-edge clean technological innovation
- longer lasting products that can be repaired, recycled and re-used
- future-proof jobs and skills training for the transition
- globally competitive and resilient industry

More specifically, among the central goals of the EU Green Deal are:

- A commitment for the EU to become carbon neutral by 2050, supported by increased use of renewable energy sources (such as onshore and offshore wind turbines and photovoltaics) in power generation, in industry and in transportation. As part of this policy, the EU has issued a series of proposals to revise and update EU legislation (the Fit for 55 package). This includes a target of 40% contribution of Renewable Energy Sources (RES) to energy generation. This target has been subsequently revised upwards to 45%, as a result of the REPowerEU initiative.

[19] https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en

- The REPowerEU plan was introduced by the European Commission aiming to reduce its reliance on imported oil and natural gas from Russia and at increasing the EU's energy independence[20].
- Investment in developing clean hydrogen production capacity, to be used as feedstock, fuel and energy carrier and storage[21].
- A 90% reduction in greenhouse gas emissions in transport by 2050, enabled by the adoption of electric vehicles (EV), with a goal of 30 million zero-emission cars and 80,000 zero-emission lorries on the streets by 2030[22].

Fluoropolymers are instrumental in achieving those strategic goals, as they are essential for many of the technologies and applications that are crucial to the EU meeting those goals:

- Fluoropolymers are used as a binder in Li-ion batteries, offering extended lifetime and performance over a broad range of conditions. Those batteries are the central component of EV and their use is expected to increase significantly until 2030 and beyond. Alternative technologies have much lower durability than fluoropolymers and will need several years of development before they can be considered as a replacement. Energy storage (e.g., from RES, which do not always produce energy during peak demand hours) is another use for batteries expected to contribute to the EU's decarbonisation goals.
- Fluoropolymers, in particular fluorinated ionomers, are a key enabling material for several hydrogen technologies, including electrolysis membranes, electrodes, as well as sealing and lining equipment for hydrogen storage and transport equipment. Electrolysis and fuel cell membranes from alternative materials have a much lower lifetime than fluoropolymer ones and cannot be considered as suitable alternatives for such applications.
- Other RES, such as wind turbines and photovoltaics, also rely on the use of fluoropolymers. Base bearings in onshore and offshore wind turbines, and photovoltaic installations are often PTFE, due to the fluoroplastic's very low coefficient of friction, allowing for more efficient designs with lower need for maintenance and wear. Fluoropolymer coatings and cable / wire jacketing and insulation, as well as lubricants, are also used in installations exposed to harsh conditions, such as for offshore wind farms.
- Fluoropolymer coatings are also used on wind turbine blades and photovoltaic panels to offer water and oil repellence and protect them from wear and corrosion, thus ensuring their efficient performance throughout their long service life.
- Seals for valves and pumps, and coatings for conventional power stations also ensure that they can operate at higher temperatures and with fewer losses, enabling more efficient power generation and reduced fuel consumption.

4.3.3.2 European Chips Act

On July 11, 2023, the EU Parliament voted in favour of the adoption of the EU Chips Act, which aims at boosting the EU's technological independence, competitiveness and resilience, and also contributes to the EU's digital and green transitions (i.e., EU Green Deal).

The European Chips Act stems from the recent chips shortage, which has disrupted some supply chains relying on them, such as the automotive, communications and machinery industries. To ensure resilience of the EU

[20] European Commission press release. REPowerEU: A plan to rapidly reduce dependence on Russian fossil fuels and fast forward the green transition. 18 May 2022. Available online at: https://ec.europa.eu/commission/presscorner/detail/en/IP_22_3131, accessed on 21 August 2023

[21] European Commission (2020). Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, on A hydrogen strategy for a climate-neutral Europe. COM(2020) 301 final. Available online at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0301, accessed on 21 August 2023

[22] European Commission (2020). Factsheet – The transport and mobility sector. Available online at: https://ec.europa.eu/commission/presscorner/detail/en/fs_20_2350, accessed on 21 August 2023.

industry, the European Chips Act aims at increasing the EU's market share in semiconductors to 20% globally by 2030 (currently it is 10%)[23] and includes a policy-driven investment package worth €43 billion until 2030[24].

The semiconductor industry is a primary focus of this initiative and fluoropolymers are essential both in the fabrication stage, e.g., as filters or equipment linings and coatings, and in the packaged chips sold to customers. Continued use of fluoropolymers will thus enable a strong growth for the EU chip manufacturing industry in the mid- and long-term.

4.3.3.3 European Critical Raw Materials Act

The European Critical Raw Materials Act is a set of actions intended to secure the EU's access to a diversified, affordable and sustainable supply of critical raw materials. It is expected that the EU's demand for certain critical and strategic raw materials, such as lithium, is expected to increase significantly in the coming years as a result of increased adoption of technologies such as electric vehicles and advanced electronics, including semiconductors (as per the targets of the European Chips Act, and the Net Zero Industry Act, for example).

Fluoropolymers are durable and stable against extreme conditions such as temperature, pressure, and corrosive or reactive chemicals. As a result, they reduce wear in various equipment they are used in. Furthermore, they protect the equipment from conditions such as moisture, oils or other chemicals, which can damage the equipment. The equipment can thus operate for a long time with low chance of failure or breakdown and little need for maintenance or replacement with the corresponding energy and raw material needs.

In conclusion, use of fluoropolymers improves the durability of the equipment in which it is used and reduces the generation of waste and consumption of often-critical raw materials and energy resources.

4.3.4 Summary of impacts in a limited derogation scenario

If use of fluoropolymers is not allowed under a limited derogation scenario, impacts to the society will be disproportionate to any benefits.

- Fluoropolymers support essential downstream operations worth hundreds of billions of euros in the EU, including some of the largest manufacturing sectors in the region, such as automotive, aerospace, chemical and medical technology industries. It is estimated that these sectors employ tens of millions of people in the EU and a large share of these jobs may be at risk under this scenario.
- The total value of fluoropolymer products manufactured or sold in the EU by FPG members participating in this study was estimated to be in the range of €1.0 – 3.0 billion in 2022. This value will be lost and is unlikely to be transferred to suppliers / manufacturers of alternatives in the EU, considering the difficulty in identifying and implementing suitable alternatives for most of the demanding applications in which fluoropolymers are used.
- Many downstream manufacturing sectors in the EU will also be impacted if they are not allowed to use fluoropolymers in their manufacturing processes, and all that is required for manufacturing at a site such as technical components, pipe linings etc. The downstream impacts are much greater than the impacts for the manufacturers. The value of products relying on the use of fluoropolymers in these sectors was estimated between € 900 and €1,400 billion in 2021 with the available information in this study, and it is expected that it will increase in the near future, as new technologies that need fluoropolymers are expected to increase in importance in the EU.
- Many technologies and products that are currently taken for granted in the EU may cease being available, just because they contain a fluoropolymer component or coating. These can include advanced electronic equipment, such as "smart" devices. In addition, adoption of emerging technologies, such as electric

[23] European Commission website – European Chips Act. Available online at: https://digital-strategy.ec.europa.eu/en/policies/european-chips-act, accessed on 21 August 2023.

[24] European Commission website – A Europe fit for the digital age. Available online at: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age_en, accessed on 21 August 2023.

vehicles, may be severely hampered, as they need fluoropolymers to perform according to their specifications, including, for example, passenger safety specifications.

- In some cases, if the downstream users decide to use non-fluorinated alternatives (if available at all), the overall performance of the product, e.g., fuel efficiency in vehicles, and breakdown rates on devices and vehicles / aircraft, may be worse. This could lead to a higher frequency of failures and breakdowns, with more need for maintenance and replacements. The result could be increased waste generation and higher raw material usage, which are against the EU's goals towards a more circular economy and reduced use of critical raw materials. This can be particularly important for products relying on the supply of strategic and critical raw materials, such as the lithium used in batteries.
- Fluoropolymers are an important contributor to safety in various aspects of the economy in the different value chains in which they are used. Preventing leaks of hazardous and potentially flammable or explosive chemicals minimises the safety risks that could arise, such as explosions, fires or health issues for workers and the local communities.
- Fluoropolymers are critical for the EU meeting the goals of its new Green Deal, in particular with regards to climate change and decarbonisation, and circular economy and sustainable use of (critical) raw materials. They are essential for the development of key technologies, such as green hydrogen generation and electric vehicles.

5. CONCLUSIONS ON THE IMPORTANCE OF FLUOROPOLYMERS

This report has presented that the benefits to the EEA society enabled by the use of fluoropolymers in a broad range of critical industry sectors are manifold. Advanced technologies and products in medical devices, transportation, energy and electrical and electronic devices would not be possible without fluoropolymer components and coatings. In addition, critical (petro)chemical, pharmaceutical and other manufacturing processes can be operated safely and reliably thanks to fluoropolymer equipment, such as sealings, pipe linings, and filtering / separation membranes.

Fluoropolymers also enable the development of technologies that contribute to the EU's decarbonisation goals and circular economy, as set forth in the EU Green Deal. Technologies such as electric vehicles, smart electricity grids and hydrogen would be pushed back several years if use of fluoropolymers is banned in the EU. They are also essential in maintaining strategic autonomy in many critical sectors of the economy, such as medical devices, transportation and aerospace, energy and semiconductors.

Overall, a limited derogation scenario could result in significant impacts not just for the fluoropolymer manufacturers, but for the whole EEA economy and society. These important functions of fluoropolymers should therefore be taken into consideration for an extended derogation for fluoropolymers.