# ECONOMIC ANALYSIS OF THE IMPACTS OF A REACH RESTRICTION ON THE MANUFACTURE, PLACING ON THE MARKET AND USE OF PER- AND POLYFLUOROALKYL SUBSTANCES

## Final Report

Report for: The European Chemicals Industry Council (Cefic)

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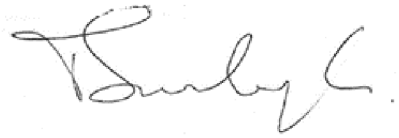

Ricardo reference:
ED14790

Date:
19/09/2023

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# EXECUTIVE SUMMARY

## INTRODUCTION

This study has been commissioned by the European Chemicals Industry Council (Cefic) to assess the business impacts to the manufacturers, importers and downstream users of per-and polyfluoroalkyl substances (PFAS) in the European Economic Area (EEA) of the REACH restriction proposal on the manufacture, placing on the market and use of PFAS.

The proposed restriction was jointly prepared by four Member States (Netherlands, Germany, Denmark, and Sweden) and Norway and is hereafter referred to as the universal-PFAS restriction proposal/ proposed restriction. Submitted to ECHA in January 2023, it would see an EU-wide ban on all manufacture, import and use of PFAS, and contains two restriction options. The preferred restriction option (RO2) includes time-limited derogations for certain uses based on the availability of non-PFAS alternatives, plus some time-unlimited derogations.

According to the standard REACH restriction timeline, the opinions of the Committee for Risk Assessment (RAC) and Committee for Socio-Economic Analysis (SEAC) should be ready by mid-2024. Subsequently, the restriction proposal will be taken forward by the Commission for discussion with Member States at the REACH Committee, bringing the publication in the Official Journal around end of 2025. Viewing the complexity and the broad scope, a delay is highly plausible. Nevertheless, these dates have been taken as reference in this study.

**This study seeks to assess the business impacts to EEA manufacturers, importers and downstream users of PFAS as a result of the PFAS restriction proposal.** It ran from January to August 2023, to estimate business impacts such as compliance and operating costs incurred by manufacturers and importers and the participating downstream users in the EEA and their responses to the regulatory changes (such as the future non-availability of products on the market, their substitution and their reformulation).

This Study has collected information from PFAS manufacturers, importers and downstream users; however, the baseline, analysis and conclusions only represent a proportion of the PFAS manufacturers/ importers and downstream users in the EEA. As an example, it should be noted that a major part of the automotive industry, cutlery and cookware sector, have not participated, with others also outstanding. Therefore, it has not been possible to develop a complete picture of PFAS use across the EEA, and the results will only be representative for the sample of companies that participated

### Overall summary of the impact and conclusions

Table 0-1 below summarises some of these impacts on key business and economic indicators of the PFAS manufacturing and importing sector against the baseline.

Table 0-1 Annualised impacts on selected business and economic indicators of the participating EEA PFAS manufacturing and importing sector, against the baseline scenario (€ 2021)

| Themes (business or economic indicators) | Scenario 1 (No derogations) | Scenario 2 (Time-limited derogations) | Scenario 3 (Narrower scope for derogations) |
|---|---|---|---|
| Turnover (first order effects) | A loss of **€3.5 billion** per year between 2024 and 2042 on average against the baseline | A loss of between **€2.1 - €2.9 billion** per year between 2024 and 2042 on average against the baseline | A loss of between **€2.5 - €3.0 billion** per year between 2024 and 2042 on average against the baseline |
| Total GVA contribution (*direct, indirect, induced*) | A loss of **€4.9 billion** per year between 2024 and 2042 on average against the baseline | A loss of **€3.0-4.1 billion** per year between 2024 and 2042 on average against the baseline | A loss of **€3.5-4.3 billion** per year between 2024 and 2042 on average against the baseline |
| Total employment contribution | 32,700 impacted jobs, on average, when compared to the baseline in any given year between 2024 and 2042 | 27,300 impacted jobs, on average, when compared to the baseline in any given year between 2024 and 2042 | 28,700 impacted jobs, on average, when compared to the baseline in any given year between 2024 and 2042 |

| Themes (business or economic indicators) | Scenario 1 (No derogations) | Scenario 2 (Time-limited derogations) | Scenario 3 (Narrower scope for derogations) |
|---|---|---|---|
| (*direct, indirect, induced*) | | | |

Table 0-2 displays some of the impacts on key business and economic indicators of the participating PFAS downstream users against the baseline.

Table 0-2 Annualised impacts on selected business and economic indicators of the participating EEA PFAS downstream users, against the baseline scenario (€ 2021)

| Themes (business or economic indicators) | Scenario 1 (No derogations) | Scenario 2 (Time-limited derogations) | Scenario 3 (Narrower scope for derogations) |
|---|---|---|---|
| Turnover (first order effects) | A loss of **€112.7 billion** per year between 2024 and 2042 on average against the baseline | A loss of **€30.9 billion** per year between 2024 and 2042 on average against the baseline | A loss of **€61.4 billion** per year between 2024 and 2042 on average against the baseline |
| Total GVA contribution (*direct, indirect, induced*) | A reduction of **€142.5 billion** per year between 2024 and 2042 on average against the baseline | A reduction of **€57.2 billion** per year between 2024 and 2042 on average against the baseline | A reduction of **€78.4 billion** per year between 2024 and 2042 on average against the baseline |
| Total employment contribution (*direct, indirect, induced*) | 863,200 impacted jobs, on average, when compared to the baseline in any given year between 2024 and 2042 | 464,900 impacted jobs, on average, when compared to the baseline in any given year between 2024 and 2042 | 682,000 impacted jobs, on average, when compared to the baseline in any given year between 2024 and 2042 |

# METHODOLOGY

## Summary of the approach

The European Commission's Better Regulation Guidelines and Toolbox[1] defines ex ante impact assessment as the process of "*gathering and analysing evidence to support policymaking*", that is, providing evidence that could inform policy decisions at the EU level ahead of implementing a policy action.

The work has followed the European Commission's Better Regulation Guidelines[2] where possible, although as this is an analysis of business impacts only, costs and benefits to human health and the environment have not been considered. It is expected that the impacts to human health and the environment will be considered in SEAC's opinion-forming processes.

The methodologies employed have been adapted based on the aforementioned scope and time available and building on the project team's practical experience in delivering Impact Assessments for private and public sector organisations. They can be summarised in five steps.

- **Step 1: Define and characterise the baseline scenario against which to assess options.** The study considered how the status quo would likely evolve, including key economic and sectoral indicators at the EEA economy, manufacturer, importer and downstream user sector levels, in the absence of the proposed restriction. This work was inspired by the latest European Commission's Better Regulation Guidelines, and particularly drawing from Tool #16 (how to identify policy options) and Tool #60 (baselines).

[1] Ibid footnote 8

[2] European Commission (2017) *Better regulation: guidelines and toolbox.* Available from: Better regulation: guidelines and toolbox | European Commission (europa.eu)

- **Step 2: Map and screen the business and economic impact categories.** A longlist of twelve economic impacts was developed and screened, based on Tool #18 (identification of impacts) of the Better Regulation Toolbox. From these, five business and economic impact categories were identified as likely to be significant for a more in-depth assessment. Across these impact categories, different types of economic costs and benefits were considered based on Tool #56 (typology of costs and benefits) of the Better Regulation Toolbox. Social and environmental impacts and, therefore, any indirect economic impacts driven by these, were not in scope of this exercise.
- **Step 3: Stakeholder consultation and evidence gathering.** Stakeholder engagement was a horizontal task, central to this study and feeding into all of the aforementioned steps. The consultation activities and data analysis carried out in this Study were based on Tool #54 (analysing data and informing policymaking) and other tools of the Better Regulation Toolbox, as pertinent. These activities included targeted consultations with manufacturers and importers of PFAS and downstream users. In addition, the consultation activities were complemented by a rapid literature review.
- **Step 4: Assess the business and economic impacts of the policy options.** Business and economic impacts were assessed by employing analytical models and methods based on Tools #58 (EU standard cost model), #61 (simulation models), #63 (cost-benefit analysis) and other tools of the Better Regulation Toolbox. These analytical approaches included: statistical techniques for the development of a counterfactual; the quantification of policy effects based on evidence collected through a business survey; and statistical techniques for the extrapolation of impacts from the survey sample to the EEA level.
- **Step 5: Conclusions.** This quantitative and qualitative evidence on business and economic impacts was employed to present the implications of the restriction proposal.

### PFAS in scope of the assessment

The following definition has been used to define the chemical scope of the restriction proposal[3].

***Substances that contain at least one fully fluorinated methyl ($CF_3$-) or methylene (-$CF_2$-) carbon atom (without any H/Cl/Br/I atom attached to it).***

***A substance that only contains the following structural elements is excluded from the scope of the proposed restriction: $CF_3$-X or X-$CF_2$-X', where X = -OR or -NRR' and X' = methyl (-$CH_3$), methylene (-$CH_2$-), an aromatic group, a carbonyl group (-C(O)-), -OR'', -SR'' or –NR''R''', and where R/R'/R''/R''' is a hydrogen (-H), methyl (-$CH_3$), methylene (-$CH_2$-), an aromatic group or a carbonyl group (-C(O)-).***

This definition is very broad and it must be acknowledged that it encompasses a range of different substances with large variation between their hazard and emission profiles.

### Selection of study participants

In close collaboration with the Cefic, a call for participants was launched at the end of December 2022. Eligible companies included those:

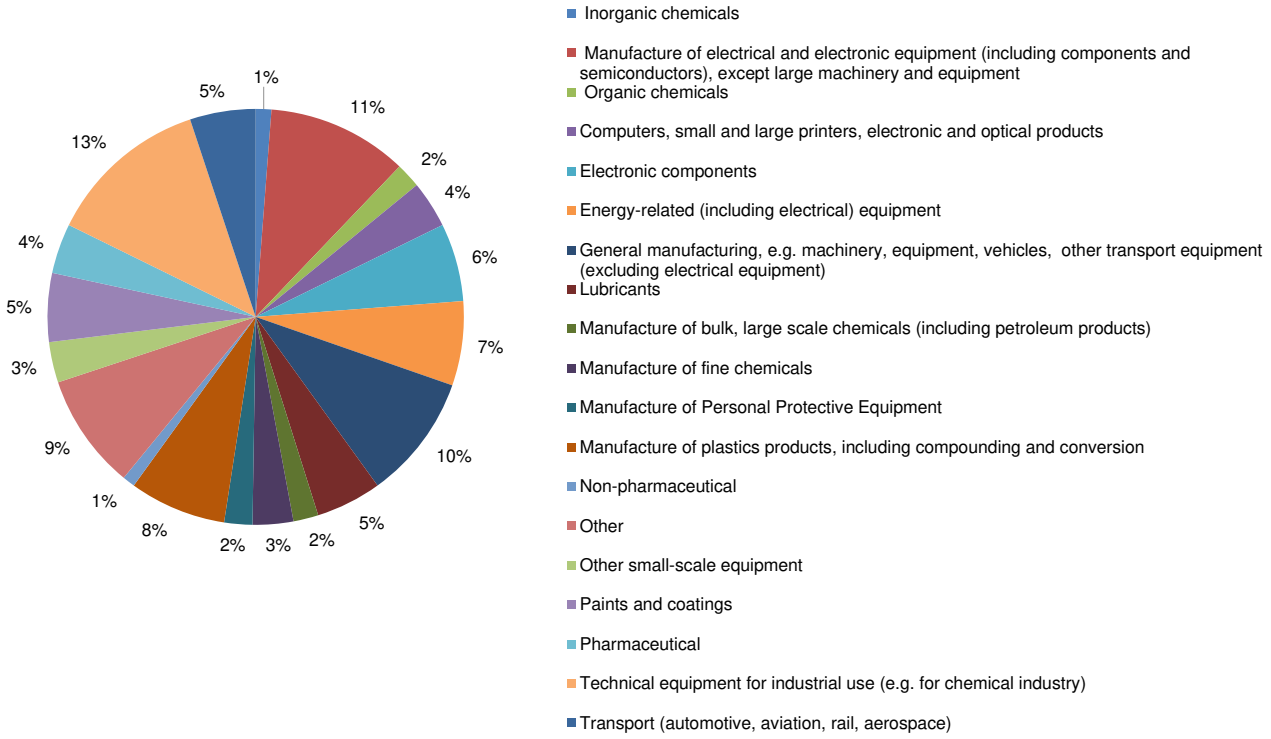
- manufacturing/ importing PFAS
- distributing PFAS substances or mixtures,
- formulating/ producing PFAS-containing end products,
- using PFAS as treatment/ processing/ producing aid for their products,
- using PFAS-containing end products,
- importing PFAS(-containing material) end products.

This resulted in 13 manufacturers and importers of PFAS and 173 downstream user companies from 30 sectors.

[3] Ibid footnote 8

Figure 0-1 below provides a representation of the applications of destination of downstream users' products containing PFAS as reported by the participants:

Figure 0-1 Sectoral breakdown of respondents




Manufacturers, importers and downstream users all responded to questions about their affected portfolio, turnover, GVA, intermediate consumption and operating costs, capital R&D expenditure and employment, as well as qualitative questions on alternatives (such as the future non-availability of substances and products/ articles on the market, their substitution, reformulation and/ or redesign).

### Assessing the business impacts from the proposed restriction

To assess the net impacts of this policy on the EEA PFAS manufacturers and importers, and downstream users, a baseline and three policy scenarios were developed:

- The sectoral **baseline** (2021-2042) was developed by aggregating evidence of turnover and growth expectations elicited in the survey to PFAS manufacturers and importers, and the participating downstream users. This baseline scenario assumes that the proposed restriction of PFAS is not implemented.
- A first policy scenario (**Scenario 1**) considers that the proposed REACH restriction on the manufacturing, placing on the market and use of PFAS is implemented in full and no derogation is applicable. This includes a transition pathway of 1.5 years until effective implementation. The restriction implies an immediate loss of portfolio that is followed by mitigatory strategies by PFAS manufacturers and downstream users, such as substitution, reformulation and other forms of innovation. As products that use PFAS are affected by the proposed restriction, they will need to be redesigned or replaced with new substances, formulas and/or processes.
- A second policy scenario (**Scenario 2**) considers that the proposed REACH restriction on the manufacturing, placing on the market and use of PFAS, is implemented following Restriction Option 2 (the preferred option) as published in the Annex XV report on 7 February 2023. This includes a transition pathway of 1.5 years until effective implementation. The restriction is followed by mitigatory strategies by PFAS manufacturers and downstream users, such as substitution, reformulation and other forms of innovation. As products are affected by the proposed restriction, they will need to be redesigned or replaced with new substances, formulas and/or processes. Derogations are implemented according to the restriction proposal, with either a 6.5-year derogation or a 13.5-year

derogation affecting only certain applications or products within each sector. Once the time-limited derogations cease, affected products could no longer be placed on the market unless they are substituted and/or reformulated.

- A third scenario (**Scenario 3**) considers that the proposed REACH restriction on the manufacturing, placing on the market and use of PFAS is implemented with a more limited scope for derogation than in Scenario 2. This includes a transition pathway of 1.5 years until effective implementation.

### Limitations and implications of the methodology

There are at least three core limitations to this impact analysis:

- **The uncertainty of EU policy proposals:**
  Considering the amount of legislative proposals currently on the table related to the EU's Green Deal and Chemicals Strategy for Sustainability, it is fair to say that many policy proposals remain uncertain and under development. This means that many policy details are not yet clear, and assumptions have been required. They have been quality assured to ensure they reflect the policy debate.
- **Limited (historical) data availability:**
  As the proposed restriction is unprecedented in its scope and number of applications targeted, there is limited historical evidence to be used as a reference. Therefore, it has been necessary to rely on consulting businesses to gather evidence as to the potential actions they may take as a response to the legislative proposals and the associated costs and benefits, as pertinent. The data gathered through the consultation exercises is limited by the sample of respondents and their understanding and assessment of how the proposed restriction may affect their operations. In fact, only 3% of total potential PFAS downstream user's turnover has been captured through the consultation. Therefore, results of this analysis only represent a lower bound of the potential impacts that the proposed restriction may have on the industry. Data to determine the full scale of the PFAS manufacture and import sector and of the size of PFAS downstream users at the EEA level was not available. Thus the analysis and conclusions are limited to the sample of consulted companies. The breakdown of this sample (e.g. SMEs versus large enterprises) and any outputs considered by firm size will need to be treated with caution and are caveated accordingly.
- **The relatively high level of complexity** for how the proposed restriction may affect the EEA industry: The proposed restriction will affect the EEA industry in multiple and complex ways. Two key drivers of impact on businesses were considered: direct and indirect restrictions of use or manufacture of PFAS; and additional regulatory burden. The extent to which these impacts affect sub-sectors and businesses, and how these businesses may respond, will vary, including whether or not businesses will discontinue, reformulate or substitute the use and manufacture of certain products. Any of these actions will incur transitional and/or recurring costs when compared to the baseline. Therefore, an informed simplification of the impact pathway, based on the project team expertise, was introduced, with inherent limitations.
- Finally, there are **known unknowns**, such as how technological progress may affect the EEA industry and whether and how this would interact with the impacts of legislation. Also, wider international trade and competitiveness are likely to affect the EEA industry but these effects are not considered in depth, primarily due to limitations in available evidence.

By including the necessary assumptions, the Study offers a workable and reasonable approach to assessing impacts of the policy options considered, albeit with limitations.

## CONCLUSIONS

This Study has collected information from PFAS manufacturers, importers and downstream users; however, the baseline, analysis and conclusions only represent a proportion of the PFAS manufacturers/ importers and downstream users in the EEA.

As an example, it should be noted that **a major part of the automotive industry, cutlery and cookware sector, have not participated, with others also outstanding**. Therefore, it **has not been possible to develop a complete picture of PFAS use across the EEA**, and the results will only be **representative for the sample** of companies that participated.

### Baseline

The majority of the surveyed PFAS manufacturers and importers do not limit their activities to the manufacture and import of PFAS; with close to half of the sample report having a wider business scope and turnover from other types of products. For example, the sample of respondents reports their total turnover to be €13.0 billion in 2021, and they employed around 33,700 people in the EEA. Of these, it is estimated that around 10,000 employees are dedicated to PFAS business lines. In 2021, these companies produced and imported PFAS into the EEA market with a turnover value around €3.2 billion. 77% of this was reportedly attributed to sales of polymeric PFAS, while 23% would come from the sales of non-polymeric PFAS. The sector's Gross Value Added (GVA) to the European economy (i.e., its direct contribution to Gross Domestic Product (GDP)) was estimated to be €1.3 billion, or 40% of their turnover.

Survey participants were asked about their expectations of growth in the long term over the next 10 years in a baseline scenario with no restriction of PFAS. On average, a Compound Annual Growth Rate (CAGR) of 4.9%[4] is estimated for turnover from PFAS, largely driven by polymeric PFAS. Similarly, the PFAS manufacturing sector's Gross Value Added is estimated to increase by a CAGR of 5.2%.

Surveyed PFAS downstream users generate a total turnover of €11,900 billion in 2021 and employ more than 35 million people. Their past growth trends are subsumed in the overall chemicals sector, already commented for PFAS manufacturers and importers.

If no more regulatory action is taken, these key trends are projected to persist in the following decades. This is the baseline or "do nothing" scenario, which is a hypothetical situation in which the proposed restriction is not implemented.

Based on the evidence collected and publicly available information, an analysis of the business impacts and knock-on implications of the proposed universal restriction of PFAS was performed, and conclusions are outlined below.

### Business impacts of the proposed PFAS restriction

Based on the evidence collected and publicly available information, an analysis of the business impacts and knock-on implications of the proposed PFAS restriction was performed, and results are outlined below.

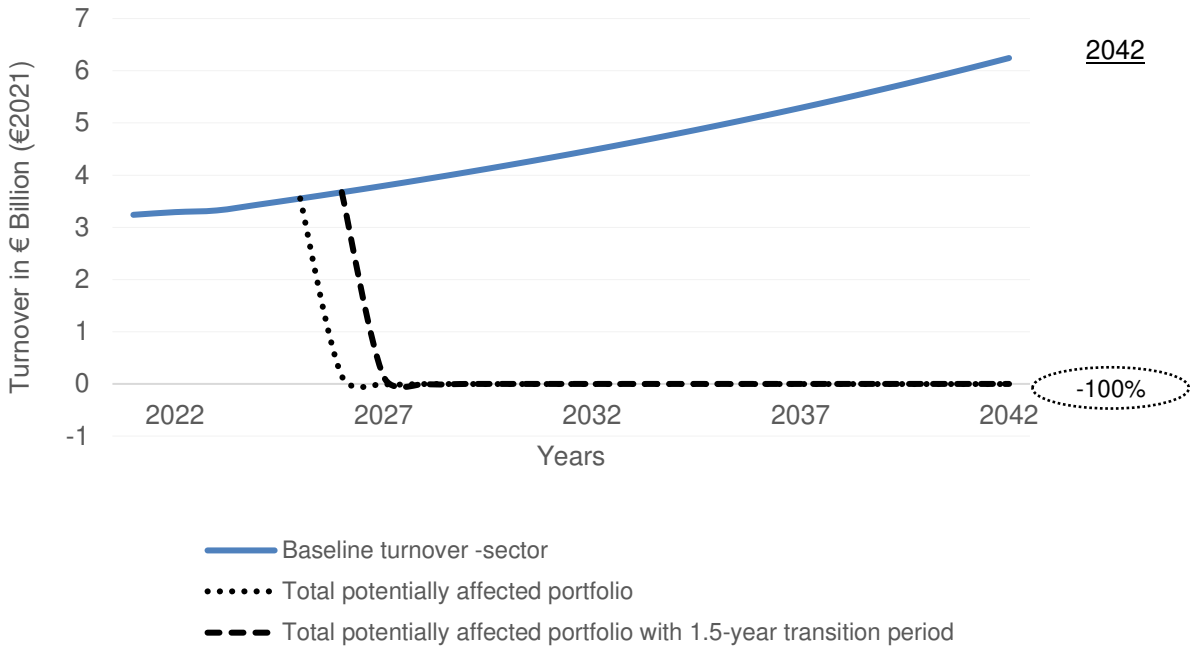
The evidence collated from the two surveys was overlayed with an expected reasonable policy implementation timeline. In essence, this step assigns the reductions in the EEA manufacturers, importers and downstream user sector's product portfolio to the moment or moments in which the proposed restriction would enter into force (i.e., first effective implementation, and potential time-limited derogations for some uses). No business response, e.g., substitution, is considered before that time. By the end of the period of assessment (2042), the size of the products in scope of the restriction proposal have been affected by the regulatory change and all potential mitigatory actions have taken place and effects materialised.

[4] All growth rates and monetary figures presented in this report are in real terms, for constant euros of 2021.

### *PFAS manufacturers and importers*

#### Affected portfolio

The manufacturers and importers' product portfolio (in terms of turnover) that is in scope of potentially being affected by the proposed restriction of PFAS (sample only), is depicted below:




100% of the turnover from PFAS would be affected by the proposed restriction, and hence, it is estimated that most of the portfolio of PFAS currently manufactured and/or sold in the EEA would no longer be placed the market, unless there were a substantial degree of success in substitution activities by PFAS importers/ manufacturers, or by other parties[5]. This means that the economic activity would eventually cease leading to potential significant reductions in market size.

With respect to the actual scope of potential substitution, reformulation and other alternatives feasible to PFAS manufacturers and importers, **it is estimated that 9% of the turnover from PFAS can be recovered by some mitigation strategies**.

#### Turnover impacts

The following graphs show the estimated impacts of the PFAS restriction on turnover from surveyed PFAS manufacturers and importers against the baseline scenario (2021).

[5] There may be an increase in market share for companies which manufacture alternatives. The manufacturers and importers who responded to this survey did not consider themselves able to manufacture alternatives in the majority of cases as they do not have suitable manufacturing facilities and would need to decommission their current facilities and invest a large amount of capital investment to support new operations. Therefore, it is assumed this action would be carried out by other chemicals companies, or even by companies within other sectors, for specific applications.

Figure 0-2 Estimated impacts of the PFAS restriction on turnover from surveyed PFAS manufacturers and importers against the baseline scenario (€ 2021). Scenario 2 (and Scenario 1 in green).

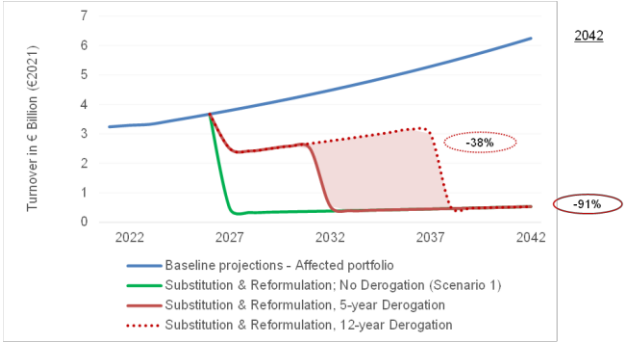
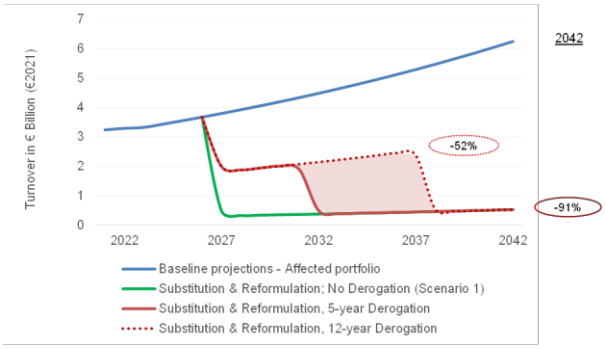



Figure 0-3 Estimated impacts of the PFAS restriction on turnover from surveyed PFAS manufacturers and importers against the baseline scenario (€ 2021). Scenario 3 (and Scenario 1 in green).




**Turnover from PFAS manufacture and import is estimated to be reduced by almost its whole value, up to 91%**, if the proposed restriction is implemented. Information reported in consultation with PFAS manufacturers and importers suggests that the scope of substitution and reformulation strategies amongst PFAS manufacturers may be limited and below 10% of the portfolio of PFAS in terms of turnover, and the low variability in responses does not suggest that it could be higher. Therefore, in annualised terms, the surveyed **EEA PFAS manufacturers and importers are estimated to lose €3.5 billion (€ 2021) of turnover each year on average over the period 2024-2042, when compared to the baseline scenario if there were no derogations (Scenario 1)**, and **between €2.1 and €2.9 billion per year on average in Scenario 2**, and **between €2.5 and €3.0 billion per year on average in Scenario 3**.

The low scope for substitution and reformulation reported by PFAS manufacturers and importers does not mean that there will be no alternatives; rather, it is expected that alternative products and technologies without PFAS that provide similar properties to PFAS products may be developed by other actors in the chemicals sector and also in other sectors, directly as alternatives to the current applications. This has been indeed clarified by some respondents, as this development might not be in the scope of activities of PFAS manufacturers and/or importers at present due to their current manufacturing facilities requiring decommissioning and new facilities needing to be built. See Section 6.3 for more insight about how substitution could happen further down the value chain.

### Total impacts on the economy (direct, indirect and induced effects)

The Study revealed that the decrease in Gross Value Added (GVA) of the EEA PFAS manufacturers and importers is likely to have knock-on effects on the sector's international supply chain (indirect or Type I effects). The direct and indirect effects are also estimated to translate into a fall in employment and thus overall compensation, which would in turn further reduce consumption and have broader implications across the economy (induced or Type II effects).

When compared to the baseline scenario, the analysis estimates that **the EEA PFAS manufacturers and importers' GVA could fall by €1.5 billion per year on average between 2024 and 2042 in Scenario 1 with no derogations, and by €0.9-1.2 billion in Scenario 2, and by €1.0-1.3 billion in Scenario 3**. These impacts are considered direct because they exclusively affect the EEA PFAS manufacturing/ importing companies. Based on this, **total decreases in GVA driven by the effects of the proposed restriction on the EEA PFAS manufacturers and importers are estimated to be €4.9 billion every year on average between 2024 and 2042 in Scenario 1, €3.0-4.1 billion every year on average between 2024 and 2042 in Scenario 2, and in Scenario 3, total GVA decreases could range from €3.5-4.3 billion every year on average, which would be equivalent to a decrease of 0.02-0.04% in the EU-27 GDP (2021).**

Portfolio losses may also materialise into **disinvestments for PFAS manufacturers and importers**, with production lines associated with PFAS potentially being dropped. **Capital expenditure related to PFAS manufacture and import is estimated to fall by around €900 million per year in Scenario 1, between €600 and €800 million per year between 2023 and 2042 in Scenario 2, between €700 and €800 million per year between 2023 and 2042 in Scenario 3**, in annualised terms against the baseline. Capex or R&D expenditure associated with products that could be discontinued as a consequence of the regulatory changes

may be unlikely to be retained in the EEA; it might be developed elsewhere, although only anecdotal evidence on this could be collected in the form of opinions by manufacturers.

#### Estimated impact on employment

The proposed restriction could also affect the sector's employment. **Based on the input from the sample of respondents, it is estimated that, by the end of 2042, around 14,300 jobs directly employed in PFAS manufacture and import could be impacted against the baseline scenario in any Scenario, which is equivalent to 30% of the surveyed PFAS manufacturers' workforce in that year[6].** This high number of job impacts is attributed to the fact that PFAS manufacturers do not expect to be able to retain business by reformulating and substituting PFAS products, although the possibility that job impacts are mitigated by relocation of workers to other business areas is considered and included in this result.

The above impacts only consider the direct impacts as a result of legislative changes to the sector. However, it is assumed that a second-order impact will follow, as impacts on the supply chain (indirect effects) and the wider EU economy (induced effects), leading to even larger reductions in the sector's contribution to employment.

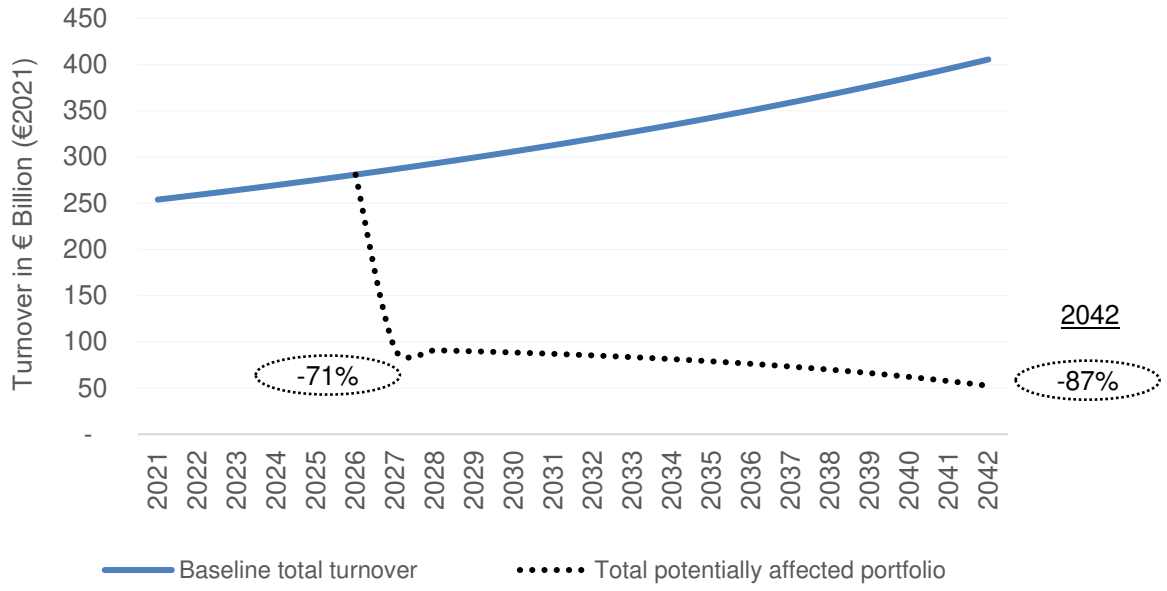
Therefore, the analysis presented in the section below for downstream users includes supply chain impacts, meaning that potential losses go beyond just products containing PFAS, and include products that use PFAS in any way in their production process as well.

### *Participating PFAS downstream users*

#### Affected portfolio

The participating downstream users' portfolio (in terms of turnover) that is in scope of potentially being affected by the proposed restriction of PFAS (sample only), is depicted below:

Figure 0-4 Product portfolio (in terms of turnover) that is in scope of being affected by the policy changes against PFAS downstream using companies' market baseline projections (sample only).




Source: Ricardo analysis based on Eurostat data and a bespoke survey to PFAS downstream users.

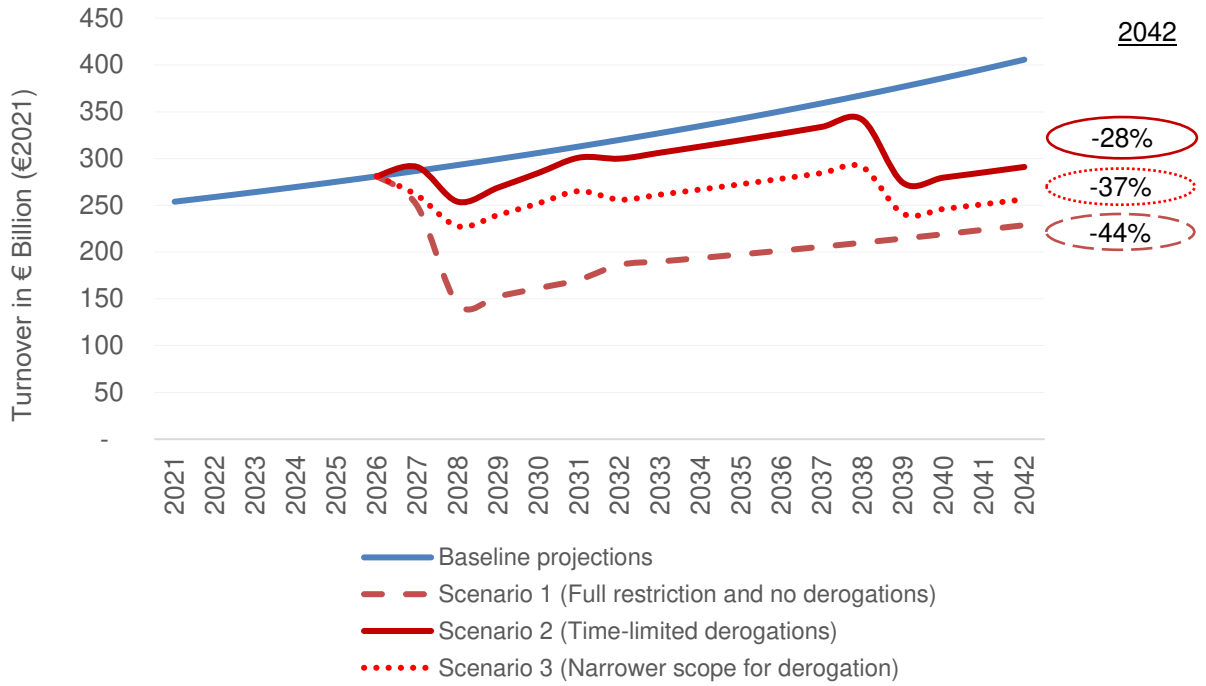
Considering the current sample of downstream user sectors and their market sizes, in 2021 around 63% of participating PFAS downstream users' turnover came from the sale of products that use or contain PFAS. However, the different growth rates of the affected sectors may increase the size of the affected portfolio over the period (71% in 2027 and 84% in 2040). In other words, those sectors that are estimated to grow at higher rates also estimated to have a larger affected portfolio (i.e., reliant on PFAS).

[6] Most PFAS manufacturers and importers also develop other economic activities, and therefore, they will maintain employees dedicated to them; in the case of our survey participants, this was estimated to be 70%.

### Turnover effect

The next graph shows the estimated impacts of the proposed PFAS restriction on turnover from the surveyed PFAS downstream users against the baseline scenario (2021).

Figure 0-5 Estimated impacts of the PFAS restriction on turnover from surveyed PFAS downstream users against the baseline scenario (€ 2021).




**Overall, for PFAS downstream users, the size of the 'total potentially affected product portfolio' was estimated to be around 63% of the total turnover from participating downstream users in our consultation, which would be equivalent to €159.2 billion in 2021**. That means that 63% of participating PFAS downstream users' income (€254.1 billion as shown in Section 5.2.2) comes from products that contain PFAS or use PFAS in their production. Evidence collected for this study suggests that, in response to the affected portfolio that may be restricted (63% of the total PFAS downstream users' portfolio), downstream users may be able to substitute and/or reformulate a significant proportion of that portfolio, with central estimates, averaged and weighted across sectors, of 37% of the affected portfolio under Scenario 1, 66% of the affected portfolio under Scenario 2, and 50% under Scenario 3, and mitigate the market losses. However, this will depend on having the time and resource to innovate, on a positive market uptake and on whether the alternative products maintain the same function. The survey suggests that the ability of businesses to substitute the affected products could range between 5% and 95% of their affected portfolio in Scenario 2 and between 0% and 95% in Scenarios 1 and 3 (in turnover terms) depending on the downstream user application, on average, although this is uncertain. Based on survey responses, participating PFAS downstream users, on average, suggest a lead time of 5.8 years to bring a substitute and/or reformulated product to the market. However, the lead time varies considerably by type of application, between an estimate of 4.1 years in *Life* sciences and 17.8 years for *Manufacture of bulk, large scale chemicals (including petroleum products)*. The lead times presented in Table 6-3 are estimates based on current understanding of R&D efforts. Where supply chain disruption is caused by the proposed restriction, such as access to raw materials, these lead times may increase significantly.

Therefore, this means that the proposed restriction, when accounting for potential business responses, could lead to a **reduction in product portfolio and business (in turnover terms) with central estimates of 44% in Scenario 1, 28% in Scenario 2, and 37% in Scenario 3 by 2042, therefore equivalent to losing €112.7 billion in Scenario 1, €30.9 billion in Scenario 2, and €61.4 billion in Scenario 3, in annualised terms over the period 2024-2042**, when compared to the baseline scenario.

### Total impacts on the economy (direct, indirect and induced effects)

The portfolio losses estimated for the participating PFAS downstream users, are expected to be accompanied by proportional reductions in operating expenditure and regulatory burden, although additional expenditure

and investment are assumed in order to develop new products and alternatives. Such impacts could have knock-on repercussions on the international supply chain (indirect effects) and the wider EEA economy (induced effects), potentially reducing the sector's contribution to GDP even further.

For surveyed downstream users, substitution and reformulation strategies require operational and capital expenditures to develop mixtures and articles with alternative formulations or substances to PFAS. As a result, they are estimated to experience GVA losses over the period 2024-2042 of between €25.1 and €66.6 billion each year on average against the baseline. **Total decreases in GVA driven by the effects of the proposed restriction on the EEA sample of PFAS downstream users are estimated to be between €57.2 billion and €142.5 billion every year on average between 2024 and 2042, which would be equivalent to decreasing between 0.4 to 1.0 percentage points off the EU-27 GDP in 2021.**

**Specifically for the participating PFAS downstream users, an additional €19.3 billion in Scenario 1, additional €29.1 billion in Scenario 2, and €23.7 billion in Scenario 3 (€ 2021) could be invested annually over 10-15 years** from the adoption of the restriction to support the changes that their companies would need to embark on to mitigate further operational and turnover losses. For these companies, this implies an increase in Capex of between 91% and 138% for the retained business during that period.

#### Estimated impact on employment

For the participating PFAS downstream users, **by the end of 2042, around 524,500 jobs could be impacted against the baseline scenario in Scenario 1, 282,600 in Scenario 2, and 414,200 in Scenario 3, respectively, which is equivalent to 13%, 7% and 10% of the surveyed PFAS downstream users' workforce in that year, respectively.**

### *Highlights of additional qualitative assessment (general concerns and experience with alternatives)*

In general, both manufacturers/ importers and downstream users are supportive of further regulation of PFAS as they acknowledge that there is a need to address the environmental, and in some cases human health, impacts that certain PFAS pose. There is consensus across respondents that the current PFAS proposal (RO2 in the Annex XV report) has a chemical scope which is too wide due to the differences in environmental and human health effects of PFAS and the criticality of certain substances within sectors that ensure the functioning of society and help to meet EU objectives such as the Green Deal and twin transitions. Concern also exists with regard to the scope of the time-limited derogations, which, in some cases, do not appear to reflect the true availability of alternatives. Some have also raised concerns related to global competitiveness of EU companies and the impact such a restriction could have on the strategic autonomy of the EU.

This is highlighted by the large majority **(85%) of survey respondents stating there are no viable alternatives for their PFAS uses available on the market that have the same properties and technical function**. The remaining respondents say there are viable alternatives to PFAS that exist on the market today and that can be used in their products.

Companies were also asked how many new products they have tried bringing to the market but failed doing so; on average, they report having failed to bring between 12 and 15 products to the market in the past, and this ranges from less than 5 to more than 20 failed alternatives to their products. Among the most common reasons for alternatives to have failed, according to respondents, are performance (e.g., durability, resistance) (28% of respondents) and regulatory costs (e.g. testing, approvals, standards) (22% of respondents).

It should be noted that an analysis of alternatives was outside of the scope of this Study and so claims made by industry on availability of alternatives and the potential impacts on product availability and function cannot be corroborated.

### Overall summary of the impact and conclusions

Table 0-3 below summarises some of these impacts on key business and economic indicators of the PFAS manufacturing and importing sector against the baseline.

Table 0-3 Annualised impacts on selected business and economic indicators of the EEA PFAS manufacturing and importing sector, against the baseline scenario (€ 2021)

| Themes (business or economic indicators) | Scenario 1 (No derogations) | Scenario 2 (Time-limited derogations) | Scenario 3 (Narrower scope for derogations) |
|---|---|---|---|
| Turnover (first order effects) | A loss of €3.5 billion per year between 2024 and 2042 on average against the baseline | A loss of between €2.1 and €2.9 billion per year between 2024 and 2042 on average against the baseline | A loss of between €2.5 and €3.0 per year between 2024 and 2042 on average against the baseline |
| Total GVA contribution (*direct, indirect, induced*) | A loss of €4.9 billion per year between 2024 and 2042 on average against the baseline | A loss of €3.0-4.1 billion per year between 2024 and 2042 on average against the baseline | A loss of €3.5-4.3 billion per year between 2024 and 2042 on average against the baseline |
| Total employment contribution (*direct, indirect, induced*) | 32,700 impacted jobs, on average, when compared to the baseline in any given year between 2024 and 2042 | 27,300 impacted jobs, on average, when compared to the baseline in any given year between 2024 and 2042 | 28,700 impacted jobs, on average, when compared to the baseline in any given year between 2024 and 2042 |

Table 0-4 displays some of the impacts on key business and economic indicators of the participating PFAS downstream users against the baseline.

Table 0-4 Annualised impacts on selected business and economic indicators of the participating EEA PFAS downstream users, against the baseline scenario (€ 2021)

| Themes (business or economic indicators) | Scenario 1 (No derogations) | Scenario 2 (Time-limited derogations) | Scenario 3 (Narrower scope for derogations) |
|---|---|---|---|
| Turnover (first order effects) | A loss of €112.7 billion per year between 2024 and 2042 on average against the baseline | A loss of €30.9 billion per year between 2024 and 2042 on average against the baseline | A loss of €61.4 billion per year between 2024 and 2042 on average against the baseline |
| Total GVA contribution (*direct, indirect, induced*) | A reduction of €142.5 billion per year between 2024 and 2042 on average against the baseline | A reduction of €57.2 billion per year between 2024 and 2042 on average against the baseline | A reduction of €78.4 billion per year between 2024 and 2042 on average against the baseline |
| Total employment contribution (*direct, indirect, induced*) | 863,200 impacted jobs, on average, when compared to the baseline in any given year between 2024 and 2042 | 464,900 impacted jobs, on average, when compared to the baseline in any given year between 2024 and 2042 | 682,000 impacted jobs, on average, when compared to the baseline in any given year between 2024 and 2042 |

Finally, substitution and reformulation could affect the performance, quality and attractiveness of the mixtures, articles and/or products placed on the market by the participating EEA PFAS downstream users. **PFAS**

**provide a variety of special properties to the products they are used in, and as such, those properties might not be fully replicated by alternative substances, mixtures and articles. Increased costs and reduced efficiency in the performance of the alternatives could lead to increased burden on industrial, professional users and consumers, possibly limiting their choice and increasing illicit trade of non-compliant products**.

The impacts estimated on the participating PFAS manufacturers and importers and PFAS downstream users that were consulted in this Study show that largest net product portfolio withdrawals and, thus, turnover losses, could primarily occur at the manufacturing/importing stage of the PFAS value chain, in relative terms. Further downstream, the consulted businesses have suggested that they would be able to partially mitigate the effects of the restriction through the development and use of substitutes and alternatives. However, this would also imply large economic losses in absolute terms (already €30.9 billion lost per year when derogations are considered, and only for the surveyed sample). Whilst the extent of possible substitution and reformulation is uncertain and highly dependent on the available time and resources to innovate, according to the PFAS downstream users engaged in the consultation, they would be able to draw on alternative formulas and/or technologies to produce their products without PFAS for between 37% and 66% of the affected portfolio of products in terms of turnover. However, this is highly uncertain and dependent on the evidence provided by the participants to the consultation for this Study. **Overall estimated impacts remain significant even in the most optimistic scenario for substitution, with 13.5-year derogations**. It should be noted that the impact on supply chains could be significant and there are likely to be knock-on implications where alternatives are unavailable. An example of which would be chlor-alkali electrolysis, which requires fluoropolymer membranes. Should these membranes be unavailable and no alternative exist, there would be an impact on the ability to manufacture hydrochloric acid (HCL) and sodium hydroxide (NaOH), which would in turn result in disruptions to the value chains of e.g. paper, aluminium , steel, water treatment, detergents.

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# Glossary

| Abbreviation | Definition |
|---|---|
| APIs | Active pharmaceutical ingredients |
| BAT | Best available techniques |
| BP | Biocidal products |
| BPR | Regulation (EU) No. 528/2012 concerning the making available on the market and use of biocidal products |
| CAGR | Compound annual growth rate |
| CAPEX | Capital expenditure |
| Cefic | European Chemical Industry Council |
| CLP | Regulation (EC) No 1272/2008 on the classification, labelling and packaging of substances and mixtures (CLP Regulation) |
| CLH | Harmonised Classification and Labelling |
| CSS | Chemicals Strategy for Sustainability |
| DU | Downstream Users |
| EC | European Commission |
| ECHA | European Chemicals Agency |
| EEA | European Economic Area |
| EU | European Union |
| EQS | Environmental Quality Standards |
| FPP4EU | FluoroProducts and PFAS for Europe |
| GDP | Gross Domestic Product |
| GVA | Gross Value Added |
| GWWL | Ground Water Watch List |
| HBM4EU | European Biomonitoring Initiative |
| IED | Directive 2010/75/EU on Industrial Emissions |
| MP | Human and veterinary medicinal products |
| MoA | Mode of action |
| OECD | Organisation for Economic Co-operation and Development |
| OPEX | Operating expenditure |
| vPvB | Very persistent, very bioaccumulative |
| PBT | Persistent, Bioaccumulative and Toxic |
| PCN | Poison Centre Notifications |
| PEM | Proton exchange membranes |
| PFAAs | Perfluroalkylated acids |
| PFAS | Perfluoroalkyl chemicals |
| PFCAs | Perfluoroalkyl carboxylic acids |
| PFOA | Perfluorooctanoic acid |

| Abbreviation | Definition |
|---|---|
| PFOS | Perfluorooctanesulfonic acid |
| PFPiA | Perfluorohexylperfluorooctylphosphinic acid |
| PPP | Plant protection products |
| PPPR | Regulation (EC) No 1107/2009 concerning the placing of plant protection products on the market |
| POPs | Persistent Organic Pollutants |
| PTFE | Polytetrafluoroethylene |
| PVDF | Polyvinylidene fluoride |
| PRODCOM | PRODuction COMmunautaire |
| Product | Substance and/ or mixture and/ or article |
| RAC | Committee for Risk Assessment |
| R&D | Research and Development |
| REACH | Regulation (EC) No 1907/2006 on the Registration, Evaluation, Authorisation and Restriction of Chemicals |
| RO | Restriction Option |
| SEAC | Committee for Socio-Economic Analysis |
| SME | Small & Medium Sized Enterprises |
| SVHC | Substances of very high concern |
| SWD | Commission staff Working Document |
| TWI | Tolerable weekly intake |
| WFD | Water Framework Directive |

# 1. INTRODUCTION

## 1.1 BACKGROUND TO THE STUDY

This study has been commissioned by the European Chemicals Industry Council (Cefic) to assess the business impacts to the manufacturers, importers and downstream users of per-and polyfluoroalkyl substances (PFAS) in the European Economic Area (EEA) of the REACH restriction proposal on the manufacture, placing on the market and use of PFAS (hereafter referred to as the restriction proposal/ proposed restriction).

The REACH restriction proposal (Annex XV report) was prepared by four Member States (Netherlands, Germany, Denmark, and Sweden) and Norway. The Annex XV report was submitted to ECHA in January 2023 and published on the ECHA website on 7th February 2023. The consultation on the Annex XV report opened on 22 March 2023 and shall run until 25 September 2023. This restriction proposal has a broad scope and covers the manufacture, placing on the market, and use of all PFAS which meet the definition[7].

The Annex XV report contains two restriction options (RO):

- RO1 – full ban with no derogations and a transition period of 18 months;
- RO2 – full ban with use-specific time-limited derogations (18 month transition period plus either a five or 12 year derogation period) and time-unlimited derogations for *inter alia* active substances in plant protection products, biocidal products and human and veterinary medicinal products.

The Dossier submitters concluded that although both restriction options are proportionate to the risk, RO2 is the most balanced option as it allows for the mitigation of unwanted effects on society linked to the lack of availability of products for which alternatives are not currently available.[8]

The restriction itself is expected to enter into force beyond the 2025 timeframe that was originally planned[9]. ECHA predicts the opinions of the Committee for Risk Assessment (RAC) and Committee for Socio-Economic Analysis (SEAC) to be ready by mid-2024[10], after which the restriction proposal will be taken forward by the Commission for discussion with Member States at the REACH Committee.

## 1.2 STUDY AIMS AND SCOPE

This study seeks to assess the business impacts to manufacturers, importers and downstream users of PFAS in the EEA as a result of the proposed restriction on the manufacture, placing on the market and use of PFAS.

The work has followed the EU Commission's Better Regulation Guidelines[11] where possible, although as this is an analysis of business impacts only, **costs and benefits to human health and the environment have not been considered**. It is expected that the impacts to human health and the environment will be considered in the SEAC opinion forming process.

This study ran from January to August 2023. The scope of this study is related to business impacts such as compliance and operating costs incurred by companies which place PFAS products on the market (manufacture, import, formulation and sale) and their downstream users in the EEA and their responses to the regulatory changes (removal from the market, substitution, reformulation).

## 1.3 REPORT STRUCTURE

This report is structured in the following sections:

- Section 1: Introduction
- Section 2: Methodology – ex ante Assessment of Business Impacts
- Section 3: Background and context

[7] ECHA (2021). Registry of restriction intentions until outcome - Per- and polyfluoroalkyl substances (PFAS). Available at: https://echa.europa.eu/registry-of-restriction-intentions/-/dislist/details/0b0236e18663449b

[8] ECHA (2023) Annex XV Restriction Report. Proposal for a restriction of Per- and polyfluoroalkyl substances (PFASs). Available at: https://echa.europa.eu/registry-of-restriction-intentions/-/dislist/details/0b0236e18663449b

[9] Chemical Watch (2022). EU PFAS restriction proposal will not incorporate 'essential use'. Available at: https://chemicalwatch.com/447571/eu-pfas-restriction-proposal-will-not-incorporate-essential-use#utm_campaign=443545&utm_medium=email&utm_source=alert

[10] Chemical Watch (2022). Delay in PFAS restriction proposal could push back EU-wide ban. Available at: https://chemicalwatch.com/437442/delay-in-pfas-restriction-proposal-could-push-back-eu-wide-ban

[11] Ibid footnote 8

- Section 4: Proposed REACH Restriction of PFAS
- Section 5: Baseline
- Section 6: Business impacts of the proposed REACH restriction of PFAS
- Section 7: Conclusion

# 2. METHODOLOGY – EX ANTE ASSESSMENT OF BUSINESS IMPACTS

This section provides an overview of the methodology used to perform an ex-ante assessment of the business impacts to EEA PFAS manufacturers and importers, and the participating downstream users, and associated economic effects as a result of the proposed universal restriction of PFAS (Section 2.1). Following this, the approach taken to develop the baseline against which the impacts were assessed is described (Section 2.2) and the processes for mapping and screening impact categories (Section 2.3) are outlined. The evidence gathering process, an essential step in this project, is summarised (Section 2.4) as well as the methods employed to assess impacts (Section 2.5). A brief presentation of limitations and quality assurance approaches are also presented (Section 2.6).

## 2.1 OVERVIEW

The European Commission's Better Regulation Guidelines and Toolbox[12] defines ex ante Impact Assessment as the process of "*gathering and analysing evidence to support policymaking*", that is, providing evidence that could inform policy decisions at the European level ahead of implementing a policy action.

This ex-ante assessment of the proposed REACH restriction of PFAS is focussed on considering how a group of consulted PFAS manufacturers/ importers and PFAS downstream users in the EEA may be affected and any potential knock-on effects on the EEA economy. It is, therefore, considered a focussed assessment of business and business-driven economic impacts.

In this context, the assessment has been developed, to the extent possible, in accordance with the European Commission's Better Regulation Guidelines. The methodologies employed have been adapted based on the aforementioned scope and time available and building on the project team's practical experience in delivering Impact Assessments for private and public sector organisations.

These methodologies are summarised in five steps.

- **Step 1: Define and characterise the baseline scenario against which to assess options.** The study considered how the status quo would likely evolve, including key economic and sectoral indicators at the EEA economy, manufacturers, importers and downstream user levels, in the absence of the proposed restriction. This work was inspired by the latest European Commission's Better Regulation Guidelines, and particularly drawing from Tool #16 (how to identify policy options) and Tool #60 (baselines). The size of the PFAS manufacturing and importing at the level of the EEA, as well as that of the participating downstream users, is unknown and lacks public statistics or rough figures that could provide an idea of its size by sales volume. Therefore, baseline trends were adapted to the size of the sample, based on the turnover value of the companies consulted, and the rest of the analysis and conclusions will be limited to the sample of companies consulted.
- **Step 2: Map and screen the business and economic impact categories.** A longlist of twelve economic impacts was developed and screened, based on Tool #18 (identification of impacts) of the Better Regulation Toolbox. From these, five business and economic impact categories were identified as likely to be significant for a more in-depth assessment. Across these impact categories, different types of economic costs and benefits were considered based on Tool #56 (typology of costs and benefits) of the Better Regulation Toolbox. Social and environmental impacts and, therefore, any indirect economic impacts driven by these, were not in scope of this exercise, which is focussed on the chemical companies consulted and industry-driven economic effects.
- **Step 3: Stakeholder consultation and evidence gathering.** Stakeholder engagement was a horizontal task, central to this study and feeding into all of the aforementioned steps. The consultation activities and data analysis carried out in this Study were based on Tool #54 (analysing data and informing policymaking) and other tools of the Better Regulation Toolbox, as pertinent. These activities included targeted consultations with PFAS manufacturers, importers and downstream users. In addition, the consultation activities were complemented by a rapid literature review.

[12] Ibid footnote 8

- **Step 4: Assess the business and economic impacts of the proposed restriction.** Business and economic impacts were assessed by employing analytical models and methods based on Tools #58 (EU standard cost model), #61 (simulation models), #63 (cost-benefit analysis) and other tools of the Better Regulation Toolbox. These analytical approaches included: statistical techniques for the development of a counterfactual; and the quantification of policy effects based on evidence collected through a business survey.
- **Step 5: Conclusions.** This quantitative and qualitative evidence on business and economic impacts was employed to present the implications of the restriction proposal. As noted, it has not been possible to quantify full sector impacts due to unknown sector size; therefore, impacts and conclusions are presented at the level of the sample of consulted companies.

The following sections describe the methods employed in steps one to five in more detail. The core limitations identified and the quality assurance approaches employed are also described.

## 2.2 DEFINE AND CHARACTERISE THE BASELINE

This study defined and characterised how the EEA Chemicals sector and 30 downstream user industries would likely evolve without the implementation of the proposed restriction, drawing from on the EC's Better Regulation Toolbox. This includes:

- Defining the baseline **policy scenario**, that is, what EU Chemicals legislation would look like in the absence of the proposed restriction;
- Identifying key economic and sectoral indicators that can be used to characterise the potential evolution of the **EEA PFAS manufacturers, importers and downstream users consulted;** and
- Quantifying how these indicators may evolve over a period of 20 years (2020-2040).

First, policy experts from the study team defined what the baseline scenario would look like in terms of EU Chemicals legislation. In particular, study team experts reviewed the existing legislation and expected changes already agreed and implemented in the legislation over the timeline. These assumptions were most useful to establish the additional requirements that may result from the implementation of the restriction proposal. In general, from a business perspective, it was assumed that the existing framework would continue broadly as-is over the period.

Secondly, the team established a set of proxy indicators of focus to characterise the baseline of the EEA Chemicals sector, the EEA PFAS manufacturers, importers and downstream users consulted, and the EEA economy, which would become the core indicators and baseline against which the policy options would be assessed. Based on their relevance and the evidence available from Cefic and Eurostat, Table 2-1 below outlines the selected indicators.

Table 2-1 Sectoral indicators selected for the baseline characterisation[13]

| Theme | Indicators |
|---|---|
| GDP and growth | • Sectoral output or production value or turnover (€ billions)<br>• Sectoral turnover (€ billions)<br>• Sectoral Gross Value Added (€ billions), approximately capturing the sector's contribution to Gross Domestic Product)<br>• Gross investment (€ billions)<br>• Operating expenditure (€ billions)<br>• Research and Development expenditure (€ billions) |
| Regulatory burden | • One-off or recurring regulatory costs (€ billions) |
| Employment | • Number of jobs supported by the sector (Number of jobs) |

[13] International trade and competitiveness were not quantitatively assessed due to the study's scope and limited availability of evidence and, therefore, a detailed baseline characterisation was not carried out at this stage.

Thirdly, historical evidence was collated from Eurostat and Cefic across each of these indicators for a 10-year period (2011 – 2021). Analytical techniques, such as econometric modelling, were employed to extrapolate, based on this evidence in a baseline scenario, how each indicator may develop over the next 20 years (2021 – 2040). This exercise provides a quantitative scenario or illustration of how the participating manufacturers', importers' and downstream users' operations could develop in the absence of further legislative action, any transformative international developments that may significantly affect the European market, and/or unknown exogenous shocks, among others.

Both the qualitative and quantitative baselines developed as part of this exercise, further described in Section 3, serve as counterfactuals against which the effects of the proposed restriction have been assessed.

## 2.3 MAP AND SCREEN THE BUSINESS AND ECONOMIC IMPACT CATEGORIES

First, a longlist of twelve (primarily) economic impact categories was developed and screened, using the language employed and structure from Tool #16 (how to identify policy options) of the Better Regulation Toolbox. This excluded any non-economic impact categories as the focus for this study was on analysing how manufacturers, importers and downstream users of PFAS may be affected economically and any potential knock-on effects on the EEA economy.

Table 2-2 Longlist of the impact categories mapped for screening

| Impact category | Impact Sub-categories |
|---|---|
| Economic | • Operating costs and conduct of business (e.g. substantive compliance costs)<br>• Administrative burdens on businesses (e.g. costs associated with notification obligations or other administrative activities)<br>• Trade and investment flows (e.g. imports or exports effects)<br>• Competitiveness (sectoral) of businesses (e.g. effects on the market share and comparative advantages in an international context)<br>• Position of SMEs (e.g. burden on small firms and impacts on their financial sustainability, etc.)<br>• Functioning of the internal market and competition (e.g. impacts on the free movement of goods)<br>• Innovation and research (e.g. stimulation or hindrance of investment in chemical alternatives, etc.)<br>• Public authorities (e.g. administrative costs from additional requirements, etc.)<br>• Consumers and households (e.g. ability to benefit from the internal market)<br>• Third countries and international (e.g. effects on EU foreign policy)<br>• Macroeconomic environment (e.g. consequences on economic growth and employment) |
| Social | • Employment (e.g. number of jobs created or lost) |

This mapping is based upon the development of impact pathways for the proposed restriction. The pathways highlighted how pertinent stakeholders may be affected: enterprises (PFAS manufacturers, importers and downstream users within NACE[14] codes A01, A02, C13, C14, C15, C19, C20, C21, C22, C26, C27, C28, C29, C30, C32, D35, E36, E37, F41, H49, H50, H51, M72, R91; additionally, subdivisions of C20.59 from PRODCOM (PRODuction COMmunautaire, Eurostat) at the level of product for lubricants), workers,

[14] Eurostat, (2008). *Statistical classification of economic activities in the European Community*. NACE Rev. 2. Eurostat Methodologies and Working papers. Available from: dd5443f5-b886-40e4-920d-9df03590ff91 (europa.eu)

consumers, EEA citizens, public authorities and third countries. Further, across each of these impact categories, different types of economic costs and benefits were considered based on approaches from the Commission's Better Regulation Guidelines.

Following this mapping, a screening exercise was conducted to identify the most significant impact categories for a more in-depth assessment. This exercise focussed on the categories of most relevance or impact on general chemicals, and PFAS manufacturers, importers and downstream users (enterprises), and considered the following:

- The magnitude of the potential impact and whether the impact is more or less significant for certain business stakeholders (i.e. SMEs versus large firms)
- The likelihood or uncertainty of an impact materialising
- The relation to the underlying initiative (i.e. whether it is a direct and/or indirect impact of the actions considered for Regulation (EC) No 1907/2006 on the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)[15])
- The relevance of the impact in meeting the EU's ambitions or commitments (i.e. whether the impact is aligned or not with the underlying objectives for amending the Regulation)
- The importance of impacts in meeting any other EU objectives and policies.

This screening exercise was based on evidence collected through secondary research and rapid literature review of published reports and papers, input from Cefic members gathered through consultation activities, and the knowledge and expertise of the project team.

As a result, five sub-categories of impact were identified as likely to be significant for a more in-depth quantitative assessment. Two additional sub-categories were considered for qualitative exploration and, where possible, quantitative assessment, depending on the evidence available and their relevance for the key business impacts of the policy options considered. Table 2-3 outlines this shortlist of impacts mapped against the indicators selected for assessment as outlined in the earlier baseline section.

Table 2-3 Shortlist of the economic impacts for more in-depth assessment, and how these are linked to the indicators selected for the quantitative assessment

| Priority | Key Impact sub-categories | Indicators selected as proxies for these key impact sub-categories |
|---|---|---|
| Primary impacts | • Operating costs and conduct of business (e.g. substantive compliance costs)<br>• Trade and investment flows (e.g. imports or exports effects)<br>• Administrative burdens on businesses (e.g. costs associated with notification obligations or other administrative activities)<br>• Position of SMEs (e.g. burden on small firms and impacts on their financial sustainability, etc.)<br>• Innovation and research (e.g. stimulation or hindrance of investment in chemical alternatives, etc.)<br>• Macroeconomic environment (e.g. consequences on economic growth and employment) Employment (e.g. number of jobs created or lost) | • Sample output or production value or turnover (€ billions), where possible by business size (**Turnover**)<br>• Sample Gross Value Added (€ billions), approximately capturing the companies' contribution to Gross Domestic Product) (**GVA**)<br>• Gross investment (€ billions) (**CAPEX**)<br>• Operating expenditure (€ billions) (**OPEX**)<br>• Research and Development expenditure (€ billions) (**R&D**)<br>• One-off or recurring regulatory costs (€ billions), where possible by business size (**Regulatory burden**)<br>• Number of jobs supported by the companies (Number of jobs) (**Employment**) |

[15] *Regulation (EC) No 1907/2006 of the European Parliament and of the Council on the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH).* The Official Journal of the European Union. Available from: https://echa.europa.eu/regulations/reach/legislation

| Priority | Key Impact sub-categories | Indicators selected as proxies for these key impact sub-categories |
|---|---|---|
| Secondary impacts | • Competitiveness of businesses (e.g. effects on the market share and comparative advantages in an international context) | This sub-category was considered qualitatively and captured indirectly as part of the analysis of turnover and GVA (since exports contribute to the sample's turnover and GVA in the EEA). |

Although these categories are likely to be most significant, the specific impacts across these categories would differ in nature, direction, and scale.

Finally, any social and environmental impacts of these policy measures and, therefore, the associated indirect economic impacts driven by these (e.g. health effects and how those may impact on productivity or the public and private health systems across the EEA), were not in the scope of this exercise, which focusses on the manufacturers. Importers and downstream users of PFAS and industry-driven economic effects.

## 2.4 STAKEHOLDER CONSULTATION AND EVIDENCE GATHERING

The evidence requirements for this assessment of business impacts are vast. There are a large number of product sectors that are potentially affected by the proposed restriction. Further, the evidence available in published reports and studies, as well as economic data of the EU and EEA manufacture, import and downstream use of PFAS already published by Cefic and Eurostat, would be insufficient to quantify potential business impacts of the proposed restriction without the introduction of a wide range of assumptions. Therefore, engaging business stakeholders to gather primary evidence on their operations and potential effects of the proposed restriction was central to this assessment.

The consultation activities and data analysis carried out in this study were based on Tool #54 (and others) of the Better Regulation Toolbox. These activities included targeted consultation activities with PFAS manufacturers, importers and downstream users. In addition, consultation activities were complemented by a rapid literature review. Due to the nature of this project, the consultation activities were not open to the wider public; for manufacturers and importers of PFAS, the consultation activities were targeted at Cefic and downstream user associations members, and the downstream user survey invitation was extended further to a large sample of target companies in the selected downstream application sectors. This was deemed appropriate for the purposes of this study as the study focusses on assessing business impacts, and the membership of Cefic and partner associations[16] are assumed to represent the majority of the EEA PFAS manufacturers and importers in terms of sales and output. **It is noted that the downstream users consultation does not capture the full scope of the market as it is so broad**.

The consultations covered:

- Part 1 – The identification of PFAS placed on the market in the EEA.
- Part 2 – The consideration of business and economic impacts of the introduction of the proposed universal restriction of PFAS.

Two separate consultation surveys were launched to cover two steps of the supply chain: manufacturers and importers, and downstream users.

The EEA includes an unknown number of manufacturers, importers and downstream users of PFAS. Although across these consultations, the ambition of the project has been to engage with a representative sample of businesses, within the limitations of time and resources, it has not been possible to obtain a reliable source for the size of PFAS manufacture and import in sales volume / turnover value, and neither for the overall economic size of chemical businesses that are downstream users of PFAS. Therefore, all analysis is limited to the sample of participants to both consultations. These consultation exercises engaged:

- Manufacturers/ importers: 13 business respondents. The sample includes one SME.
- Downstream users: 173 business respondents of the EU's PFAS use downstream. The sample includes 48 SMEs as well.

[16] 670 business members and affiliates, information gathered from: https://cefic.org/about-us/membership/

Both samples, therefore, comprise a potentially disproportionate number of large firms. This is not deemed a significant issue for this assessment, especially since the analysis will be limited to the sample itself and it is judged that this would lead to relatively more conservative estimates as experts expect that **SMEs might be more severely affected by the policy options considered in this Study**[17].

The engagement activities are described in more detail in Section 2.4.1.

Definitions and guidance documents were provided to aid completion of both surveys and to try to ensure that companies were approaching the consultation in the same way.

### 2.4.1 Design and implementation of questions related to economic impacts

The consultation on the restriction proposal aimed to collect evidence that would form the basis for an assessment of the **business impacts to manufacturers, importers and downstream users of PFAS in the EEA sample consulted,** once businesses respond to the legislative changes e.g. through substitution and/or reformulation[18]; and quantify key knock-on effects based on evidence collected from businesses directly, as much as possible.

These surveys were designed to elicit evidence and informed views from businesses through:

- Gathering data about the respondents, in terms of their size, activities, main country of operation, etc.
- Seeking to form a baseline of key economic and regulatory indicators, such as their turnover, investment, expenditures, employment, and regulatory burden.
- Considering direct business responses and associated costs and benefits (e.g. substitution, reformulation; investments; expenditures; and employment) over at least 10-15 years from adoption of the proposed restriction.
- Collecting information on other economic impacts, primarily qualitative (e.g. imports/exports and competitiveness).

Both surveys covered all of the key business and economic impacts that were screened as potentially most significant (Section 2.4). The types of questions covered across these key business impacts and/or proxies for these impacts are outlined in Table 2-4.

Table 2-4 Topics of questions covered by the economic impact survey

| Policy, key business impacts or proxies | Information sought by the survey for evidence on operations in the EEA (not an exhaustive list) |
|---|---|
| Policy | • Establishing the relevance of certain policies and/or legislation for each respondent and their suppliers |
| Turnover / business size | • 2021[19] turnover of products sold, number of products, and gross operating profit; annual growth expected in the absence of the proposed universal restriction of PFAS over 10 years; annual growth expected upon adoption of the policy changes over 10 years.<br>• Percentage (or sales value) of the affected portfolio that would be in scope for substitution and/or reformulation; potential pass through of potential regulatory burden; |
| OPEX | • 2021 annual operating costs; annual growth expected in the absence of REACH restriction over 10 years; annual growth expected upon adoption of policy changes over 10 years (for the retained business) |

[17] The sample of SME respondents in the downstream users sample has a size of 48 across 30 different sectors, which implies that any estimates for this group should be taken as indicative only.

[18] Typical business responses to regulation that may result in market losses are: substitute the substance, where there is a technically and economically feasible alternative; and reformulate away from the substance (or the levels subject to restriction).

[19] 2021 was taken as the baseline year for eliciting evidence of potential impacts from businesses through survey, as 2020 is not considered representative of normal operating conditions of the EU chemicals sector due to the COVID-19 pandemic, and 2022 was too recent to obtain reliable data at the moment of the consultation activities.

| Policy, key business impacts or proxies | Information sought by the survey for evidence on operations in the EEA (not an exhaustive list) |
|---|---|
| | • Recurring costs of substitution and/or reformulation, across different cost categories. |
| CAPEX | • 2017-2021 average annual total capital investment; annual growth expected in the absence of the proposed restriction of PFAS over 10 years; annual growth expected upon adoption of policy changes over 10 years<br>• Recurring costs of substitution and/or reformulation, across different cost categories |
| R&D | • Level of operating expenditure/ capital investment devoted to R&D expenditure in the EEA and expected evolution in the absence of the proposed restriction of PFAS; annual growth expected upon adoption of policy changes over 10 years. |
| Employment | • 2021 employment; annual growth expected in the absence of the proposed restriction of PFAS over 10 years; annual growth expected upon adoption of policy changes over 10 years<br>• Potential labour requirements for substitution and/or reformulation; additional administrative activities associated with the potential legislative changes |
| Other economic impacts | • Consideration of impacts on imports and exports<br>• Qualitative effects on competitiveness |

Different approaches were employed to elicit evidence and informed views from businesses (e.g. more explicit or implicit approaches to gather evidence of key potential business impacts) to offer an opportunity to compare and contrast the impacts expected from an analysis of sample responses and review, adjust and/or qualify the results as required.

For example, survey respondents were asked to provide their 2021 turnover and their estimated turnover growth over the next 10 years in the absence of the proposed universal restriction of PFAS (i.e. the baseline). Based on this baseline, businesses were asked to consider how they might respond to the potential policy requirements on their affected portfolio, as follows:

- Likelihood of forgoing production of PFAS
- Recovery of losses
- Ability to substitute discontinued polymers and percentage of demand that could be met
- The extent to which they may pass through additional regulatory burden via adjustment of prices to their customers
- The responsiveness of their clients to price changes.

The data obtained in this consultation is deemed sensitive under competition law. In order to ensure compliance with confidentiality and anonymity, access to responses to the consultation was limited to study team members from Ricardo and the data was stored in a location with limited access rights. Cefic, participating associations and their members did not have access to any data, other than that which they submitted themselves. In the analysis of the data, Ricardo followed the statistical rules of Cefic, ensuring that all data was aggregated[20] and anonymised to prevent reverse engineering of data.

Following this, businesses were also asked, explicitly, to provide an estimate for how the adoption of the restriction proposal could affect turnover growth over the period. These more explicit views from businesses

[20] The aggregated data used always came from more than five independent companies, the latter being understood as the collection of undertakings whose relations with the company participating to the statistical exercise come within the terms of one or more of the sub-paragraphs of Article 5(4) of the EU Merger Regulation. Any input of less than 5% of the total volume reported by companies was not taken into consideration. Even when aggregated, the data did not come from one company with more than 70% of the total volume. No price information was included in the report.

were only used as a comparison or contrast to the more implicit analysis of impacts that is based on detailed evidence of the affected portfolio and potential business responses.

Our analysis is based on bottom-up data, and that is compared with the top-down views shared by businesses. This two-pronged approach for eliciting evidence and/or informed views from the surveyed companies, therefore, allowed the project team to estimate the impact on turnover by triangulating detailed evidence of the affected portfolio and the potential business responses (e.g. substitution, etc.), which is referred as the implicit/bottom-up analysis; and compare and contrast the outputs of said analysis with the explicit/top-down views of impact shared by businesses.

Finally, it is noted that 2021 was taken as the baseline year for eliciting evidence of potential impacts from businesses through survey, as 2020 is not considered representative of normal operating conditions of the EEA manufacturers, importers and downstream users of PFAS due to the COVID-19 pandemic and 2022 was too recent to have reliable data at the moment of consultation activities. This means that the information gathered referred to potential impacts with regards to 2021 business operations. Nevertheless, the information gathered was triangulated with available projections from the European Commission as to the expected recovery from the pandemic to generate a baseline and Impact Assessment that aligns with said expectations.

## 2.5 ASSESS THE BUSINESS AND ECONOMIC IMPACTS OF THE PROPOSED RESTRICTION

Business and economic impacts were assessed by employing analytical models and methods in line with the Commission's Better Regulation Guidelines. These analytical approaches include statistical techniques for the quantification of policy effects based on evidence collected through a business survey.

The **analysis of impacts** was carried out against the baseline (or counterfactual). The following steps were taken:

- **Quantifying the retained business operations for the sample upon adoption of the legislative change:** Assessment of the effects on the size of business operations upon adoption of a restriction of PFAS, having identified the portfolio of products that is likely to be affected (i.e., the 'affected portfolio') by these legislative changes. This assessment triangulates responses to multiple survey queries that seek to unveil the potential effects of the legislative changes, after taking into account expected business responses such as substitution and/or reformulation and changes to product pricing and associated customer responses.
- **Assessing the sample impacts across selected categories** (or proxies)
    - Implicit approach (preferred): An assessment of potential impacts from the restriction proposal based on the triangulation and analysis of multiple queries asking about specific actions that business may take due to the adoption of changes to legislation (e.g. estimating changes in operating expenditure based on estimated changes to the size of operations and the additional burden that would be expected from changes in the manufacturing processes and administrative tasks, among others)
    - Explicit approach (alternative for comparison or check): Using respondents' explicit views as to how much a particular business or economic variable may be affected as a result of the restriction proposal (e.g., estimating changes on operating expenditure based on explicit views of businesses)
    - Whilst the product portfolio of EEA PFAS manufacturers, importers and downstream users could be affected by the restriction proposal, there are multiple actions companies could take to mitigate the business impacts. However, these are complex and not easy to assess at a high level and, thus, it is expected that the explicit business views could have limitations. That is why an implicit approach that exploits all of the evidence presented by businesses is preferred.
- **Adjusting these impacts based on the assumed policy implementation timetable:** 2025 has been assumed as the year in which they come into force all at once.

- **Estimating the potential effects on GDP and employment at EU level**[21], by considering the indirect and implicit effects of the sample of companies consulted, as changes in Gross Value Added and Employment (e.g., employing Input-Output methods).

For each indicator, there were specific approaches, considerations and/or assumptions employed.

## 2.6 LIMITATIONS AND QUALITY ASSURANCE

The limitations to the impact analysis as well as the quality assurance (QA) approach employed are outlined briefly in this section.

### 2.6.1 Limitations

There are at least three core limitations to this impact analysis. These are the uncertainty of the policy proposals, the relatively high level of complexity for how these policy options may affect the EEA industry, and the availability of quality data.

First, the policy proposals remain uncertain and under development. This means that the policy details are not yet clear, and assumptions have been required. Policy assumptions have been quality assured to ensure they reflect the policy debate. As discussions are ongoing, the assumptions made in this assessment may not accurately reflect the restriction that enters into force, in particular the derogations that may be carried forward. However, the assessment carried out and its outputs are highly dependent on these assumptions and, therefore, reflect the same level of uncertainty.

Secondly, the data available has limitations. There is limited historical evidence of relevance, given that the policy options considered for future implementation go over and above any other policies implemented in the EEA and internationally. It has been, therefore, necessary to rely on consulting businesses to gather evidence as to the potential actions they may take as a response to the restriction proposal and the associated costs and benefits, as pertinent. The data gathered through the consultation exercises is limited by the sample of respondents and their understanding and assessment of how the policies considered may affect their operations. Data to determine a full size of the PFAS manufacture and import sector, and of the size of PFAS downstream users at the EEA level was not available, so the analysis and conclusions are limited to the sample of consulted companies. The breakdown of this sample (e.g. SMEs versus large enterprises) and any outputs considered by firm size will need to be treated with caution and caveated accordingly.

Thirdly, the policies under consideration will affect the EEA industry in multiple and complex ways. This study has limitations by design, in that it is focussed on PFAS manufacturers and importers, and downstream users across 30 industrial sectors, therefore business impacts and associated knock on-effects (excluding other social and environmental, as well as economic impacts driven by other dynamics outside of the chemicals sector). In this context, two key impact drivers of impact on businesses were considered: direct and indirect restrictions of use or manufacture of chemicals; and additional regulatory burden (such as the cost of developing alternatives, testing new products, etc.), thus potentially affecting the economic viability of certain operations. The extent to which these impacts affect sub-sectors and businesses, and how these businesses may respond, will vary, including whether or not businesses will discontinue, reformulate or substitute the use and manufacture of certain products. Any of these actions will incur transitional and/or recurring costs when compared to the baseline. Therefore, an informed simplification of the impact pathway, based on the project team expertise, was introduced, with inherent limitations.

The analysis, therefore, assumes that the proposed REACH restriction of PFAS will lead to the discontinuation of the use and/or manufacture of the affected products unless they can be substituted, reformulated and/or subject to redesign. These business responses are estimated to result in additional costs, when compared to the baseline, albeit it is assumed that they would be economically feasible (it is assumed that alternatives with non-affordable costs will not be developed).

Moreover, there are also a number of known unknowns, such as how technological progress may affect the EEA industry and whether and how this would interact with the impacts of legislation. Further, wider international trade and competitiveness are likely to affect the EEA industry but these effects are not

[21] Input-output tables are limited to the EU-27, and therefore knock-on effects refer only to the EU.

considered in depth, primarily due to limitations in the evidence available. These are further sources of uncertainty.

These, and other assumptions, offer a workable and reasonable approach to assessing impacts of the policy options considered, albeit with limitations.

### 2.6.2 Quality assurance

A number of approaches were employed to assure the methodology, analysis and outputs throughout the project, including with experts within the project team. This included:

- **Baseline**: The methodology and analysis of publicly available data to produce baseline projections for business and economic indicators was reviewed by an expert economist. Feedback was provided and considered to produce final outputs. The data available is limited and it has not always been possible to take into account complex or emerging trends in the sector and the EEA economy, such as e.g. technological progress and how this may affect the evolution of employment per unit of turnover. This introduces significant uncertainty to the projections. However, it was concluded that these estimates offer a practical and reasonable counterfactual against which to consider the effects of policy options in this context of uncertainty.
- **Policy assumptions:** An ex-ante assessment of impacts requires concrete and specific policy options. A number of informed assumptions (Section 4.1 and Section 4.2) were developed based on the restriction proposal. These assumptions were checked with chemicals policy experts and discussed with a group of experts from Cefic. The output provides an informed view of the types of policies that are being considered by the European institutions and their potential timetable.
- **Consultation design and implementation:** Consultation questionnaires, including a bespoke business survey, were designed and reviewed by experts in chemicals businesses, chemicals policy and Impact Assessments following the European Commission Better Regulation Guidelines. Technical experts from Cefic and their membership were also engaged to ensure that the approach was proportionate and practical whilst meeting the project's needs, including in terms of the number and quality of responses that could be expected. Multiple rounds of feedback were implemented to quality assure the design of the questionnaires and strike a balance between the details required and the practicalities of the time and resources available to complete and subsequently assess the data gathered.
- **Data gathered:** The Consultation questionnaires produced the core data employed for the quantitative Impact Assessment. The data 'cleaning' and parametrisation was checked for any structural challenges and any feedback was fed through the final dataset analysed. The data was checked, reviewed and tested using standard visualisation techniques and exploring the mean, median and standard deviation or spread of responses to a random selection of survey responses. Where any potential issues were identified, the project team followed up with a random selection of respondents to develop an informed approach to resolve these potential issues. For example, when responses suggested big annual changes in key performance indicators such as turnover, the interpretation of the questions were checked to corroborate whether answers referred to annual or cumulative changes over a period of 10 years. Tests were carried out for potential outliers. The final dataset, therefore, represents the best available evidence from businesses as to their baseline operations and potential responses to the policy options considered.
- **Impact analysis:** The project team carried out an analysis of selected impact categories, relying primarily on the data collected by consulting Cefic and partner associations members. This analysis was primarily done in MS Excel and complemented by statistical analysis in Stata. There were three rounds of quality assurance of this work. The approach to assessing impacts was reviewed by chemicals policy and Impact Assessment experts and iterated. Following this, the analysis carried out in MS Excel was also reviewed. The flow of information, the implementation of the methodology, and the individual formulae were checked and corroborated. The outputs were also contrasted with hypotheses and, where potential issues were identified, a more in-depth review was carried out to ensure the analysis was carried out effectively.

The assessment and outputs presented in this report have, therefore, been reviewed and checked by a number of experts and represents an informed view of the potential impacts of the policy options considered, caveated by the limitations outlined and inherent to an ex-ante Impact Assessment.

# 3. BACKGROUND AND CONTEXT

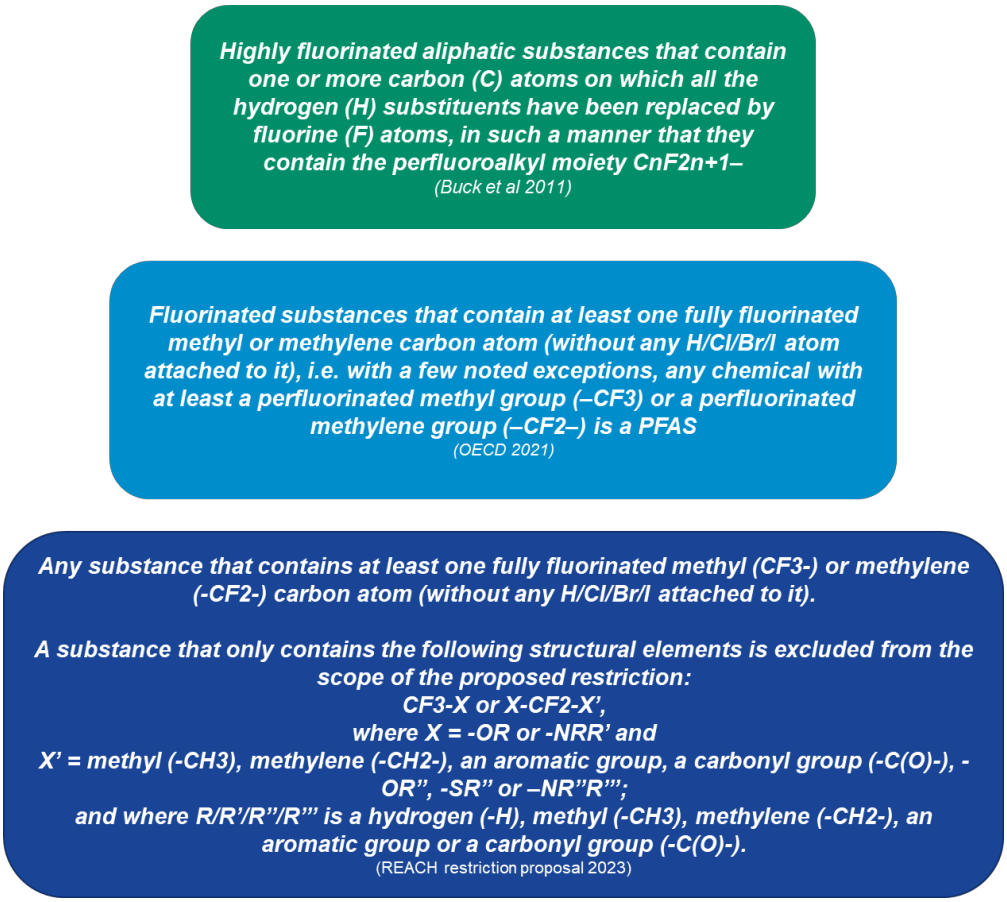
This section provides an introduction to PFAS, their production and uses, and their current and future regulation. It is structed as follows:

- **Section 3.1** – PFAS definition and chemistry; PFAS applications, typical PFAS exposure pathways, and health effects of PFAS
- **Section 3.2** – Current and future regulation of PFAS

## 3.1 USE OF PFAS

PFAS are a group of organofluorine substances that are used in a wide range of applications. The PFAS definition has evolved over time (see Figure 3-1), with the first definition provided by Buck et al in 2011[22]. This definition was revised by the OECD in 2021[23] to make it more comprehensive in order to capture all compounds with shared structural traits and address ambiguities in the descriptions. The definition used in the REACH restriction proposal is heavily based on that of the OECD. It should be noted that the OECD has stated that gaps in the PFAS definition may be identified in future as new knowledge is generated, so an iteration approach to defining PFAS should be taken[24].

Figure 3-1 Evolution of PFAS definitions



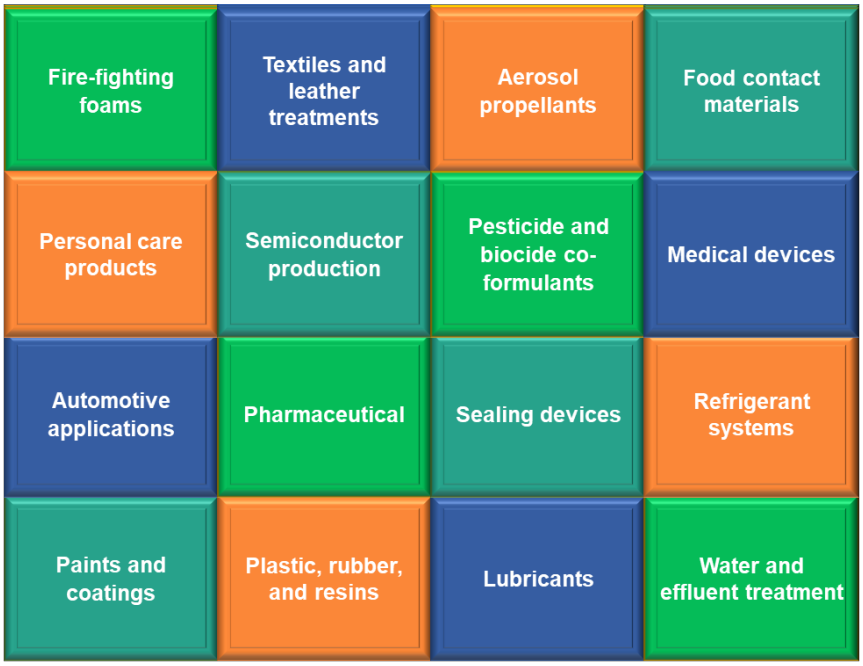

[22] Buck et al. (2011). Perfluoroalkyl and polyfluoroalkyl substances in the environment: Terminology, classification, and origins. Integrated environmental assessment and management, 7(4), 513-541. Available at: https://setac.onlinelibrary.wiley.com/doi/10.1002/ieam.258

[23] OECD (2021) Reconciling Terminology of the Universe of Per- and Polyfluoroalkyl Substances: Recommendations and Practical Guidance. Available at: https://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=ENV/CBC/MONO(2021)25&docLanguage=En

[24] OECD (2021) Reconciling Terminology of the Universe of Per- and Polyfluoroalkyl Substances: Recommendations and Practical Guidance. Available at: https://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=ENV/CBC/MONO(2021)25&docLanguage=En

Fully fluorinated carbon chains, where all hydrogen atoms have been replaced by fluorine, attached to functional groups, such as carboxylic or sulfonic acids, are referred to as perfluroalkylated acids (PFAAs) and are well-known PFAS, with examples including perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS)[25]. The carbon-fluorine bond is very strong which imparts a high chemical and thermal stability to these substances[24]. Certain PFAS have useful water and oil repellent properties, which make PFAS effective surfactants and surface protectors for a wide range of commercial and consumer applications and products. Consequently, PFAS have been manufactured in large quantities since the 1940s[30]. More than 200 uses of PFAS across 64 use categories have been described in a recent review[26] (examples provided in Figure 3-2), with almost all industrial sectors using PFAS in some form. A full list of the use categories stated in the aforementioned review can be found in Table 7-5 of Appendix I.

Figure 3-2 Examples of applications using PFAS (source: developed by Ricardo)




Glüge *et al.*[27] set out a prioritised list of use categories that special attention should be given to for reducing/eliminating the use of PFAS. These include: firefighting foams, processing aids in the polymerisation of fluoropolymers; surface protection of textiles, leather, and paper; coatings, paints, and varnishes; electronics; production of plastic and rubber; and use in machinery manufacturing.

Many PFAS are expensive to produce, for example, PFAS-based surfactants cost around 100 – 1,000 times more than conventional hydrocarbon surfactants per unit volume, meaning they are often used when there are no alternatives delivering the same performance standards, or where PFAS can be used in much smaller quantities than other substances[28]. To date, there are few products or technologies that have emerged that can match the performance of fluorinated surfactants and fluorinated polymers[29]. Therefore, some uses of PFAS may be essential to the health, safety or the functioning of society where there are no currently available alternatives, and for which finding suitable alternatives may be challenging. The large number of uses of PFAS highlights the difficulty of phasing out this group of substances and the scale of the task faced by regulators and industry.

[25] COM (2020). Commission Staff Working Document - Poly- and perfluoroalkyl substances (PFAS). Available at: https://ec.europa.eu/environment/pdf/chemicals/2020/10/SWD_PFAS.pdf

[26] Glüge et al. (2020). An overview of the uses of per-and polyfluoroalkyl substances (PFAS). Available at: https://engrxiv.org/preprint/view/1098/2335

[27] Glüge et al. (2020). An overview of the uses of per-and polyfluoroalkyl substances (PFAS). Available at: https://engrxiv.org/preprint/view/1098/2335

[28] Thomas RR. Fluorinated surfactants. In: Farn RJ, ed. Chemistry and Technology of Surfactants. Blackwell Publishing; 2006.

[29] Krafft and Riess (2015). Per- and polyfluorinated substances (PFASs): Environmental challenges. Available at: https://www.sciencedirect.com/science/article/pii/S1359029415000394

Information on the identity, production, uses, releases, and environmental presence of PFAS on the global market is limited due to the complexity of the issue, data scarcity and fragmentation, and data confidentiality[30]. Nevertheless, large-scale efforts have been made by several organisations to identify PFAS that may be present on the global market and compile inventories. Approximately 4,700 PFAS have been identified by the OECD[30], although this list is not exhaustive due to data gaps and limitations. More recently, it has been reported that over 6 million substances can be considered PFAS under the OECD definition (i.e. contain at least one saturated $-CF_2-$ or $-CF_3$ group)[31].

The stakeholder consultation carried out for this Study asked respondents to indicate the types of PFAS that they use per sector. Table 3-1 provides an overview of these responses, with more detail presented in Appendix 3. It can be seen from responses to the consultation that certain PFAS are more widely used than others, e.g. fluoropolymers , perfluoroalkanes and F-gases are used in all sectors included in this study. These PFAS may be used directly in the manufacture of products within these sectors, or they may be used in the technical equipment needed to manufacture products.

[30] OECD (2018). Toward A New Comprehensive Global Database of Per- and Polyfluoroalkyl Substances (PFASs). Available at: https://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=ENV-JM-MONO(2018)7&doclanguage=en

[31] PubChem (2022) PFAS and Fluorinated Compounds in PubChem Tree, Available from: https://pubchem.ncbi.nlm.nih.gov/classification/#hid=120

## Table 3-1 Overview of PFAS use per sector (stakeholder consultation responses)[32]

| | 1. Agri | 2. Textiles | 3. PPE | 4. Plastics | 5. Paints & coatings | 6. Lubricants | 7. Bulk chemicals | 7.1 Organic | 7.2 Inorganic | 8. Fine chemicals | 8.1 Non-pharma | 8.2 Pharma | 9. Medical devices | 10. Electrical &electronic | 10.1 Electronic components | 10.2 Computers/ other | 10.3 Medical equipment | 10.4 Energy-related | 10.5 Other small-scale | 11. General manufacturing | 11.1 Transport | 11.2 Technical equipment | 12. Building & construction | 13. Power | 14. Water & sewage | 15. R&D | 15.1 Scientific R&D | 15.2 Life Sciences |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Acrylates** | | | | | | | | | | | | | | | x | | | | | | | | | x | | | | |
| **Alcohols** | | | | | | | | | | | | | | | x | | | | | | | | | x | | | | |
| **Amines** | | | | | | | | | | | | | | | **x** | | | | | | | | | **x** | | | | |
| **Aromatic side chains** | | | | | | | | | | | | | | | x | | | | | | | | | x | | | | |
| **Carbonyls** | | | | | | | | | | | | | | | x | | | | | | | | | x | | | | |
| **Carboxylic acids** | | | | | | | | | | | | | | | x | | | | | | | | | x | | | | |
| **Diiodides** | | | | | | | | | | | | | | | x | | | | | | | | | x | | | | |
| **Epoxides** | | | | | | x | | | | | | | | | x | | | | | | | | | x | x | | | |
| **Ethers/diethers** | | | | | | | | | | | | | | | x | | | | | | | | | x | | | | |
| **F-Gases (HFCs, HFOs, …)** | **x** | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| **Fluoropolymers** | **x** | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| **Fluorotelomer-based compounds** | | | | | | | | | | | | | | x | | | | x | x | x | | x | | | x | x | x | x |
| **Fluorotelomers** | | | | | | | | | | | | | | x | x | | | x | | | | x | x | x | x | | | |
| **Halides** | | | | | | | | | | | | | | x | x | | | | | | | | | x | | | | |

[32] 1. Agriculture, forestry, fishery; 2. Manufacture of textiles, leather, fur; 3. Manufacture of Personal Protective Equipment; 4. Manufacture of plastics products, including compounding and conversion; 5. Paints and coatings; 6. Lubricants; 7. Manufacture of bulk, large scale chemicals (including petroleum products); 7.1 Organic chemicals; 7.2 Inorganic chemicals; 8. Manufacture of fine chemicals; 8.1 Non-pharmaceutical; 8.2 Pharmaceutical; 9. Medical devices; 10. Manufacture of electrical and electronic equipment (including components and semiconductors), except large machinery and equipment; 10.1 Electronic components; 10.2 Computers, small and large printers, electronic and optical products; 10.3 Medical equipment; 10.4 Energy-related (including electrical) equipment; 10.5 Other small-scale equipment; 11. General manufacturing, e.g. machinery, equipment, vehicles, other transport equipment (excluding electrical equipment); 11.1.Transport (automotive, aviation, rail, aerospace); 11.2 Technical equipment for industrial use (e.g. for chemical industry); 12. Building and construction work; 13. Electricity, steam, hydrogen, gas, batteries and fuel cells; 14. Water supply, water treatment and sewage treatment; 15. Research and development; 15.1 Scientific R&D; 15.2 Life Sciences

| | 1. Agri | 2. Textiles | 3. PPE | 4. Plastics | 5. Paints & coatings | 6. Lubricants | 7. Bulk chemicals | 7.1 Organic | 7.2 Inorganic | 8. Fine chemicals | 8.1 Non-pharma | 8.2 Pharma | 9. Medical devices | 10. Electrical &electronic | 10.1 Electronic components | 10.2 Computers/ other | 10.3 Medical equipment | 10.4 Energy-related | 10.5 Other small-scale | 11. General manufacturing | 11.1 Transport | 11.2 Technical equipment | 12. Building & construction | 13. Power | 14. Water & sewage | 15. R&D | 15.1 Scientific R&D | 15.2 Life Sciences |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Ketones** | | | | | | | | | | | | | | | x | | | | | | | | | x | | | | |
| **Morpholines** | | | | | | | | | | | | | | | x | | | | | | | | | x | | | | |
| **Perfluoroalkane sulfonamides** | | x | | | | | | | | | | x | | x | x | x | | x | x | x | | x | | | x | x | x | x |
| **Perfluoroalkane sulfonyl fluorides** | | | | x | | | | | | | | | | x | x | x | x | x | x | x | | x | | x | x | x | x | x |
| **Perfluoroalkanes (excl. F-Gases)** | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| **Perfluoroalkyl acids** | x | x | x | x | x | x | | x | | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| **Perfluoroalkyl aldehydes** | | | | | | | | | | | | | | x | | | | x | x | x | | x | | | x | x | | x |
| **Perfluoroalkyl iodides** | | | | | | | | | | | | | | x | | | | x | x | x | | x | | | x | x | x | x |
| **Perfluoropolyethers** | | | | x | x | x | | | | | | | | x | x | x | x | x | x | x | x | x | | x | x | x | x | x |
| **Phosphates** | | | | | | | | | | | | | | | x | | | | | | | | | x | | | | |
| **Phosphoniums** | | | | | | | | | | | | | | | x | | | | | | | | | x | | | | |
| **Poly-fluorinated n-alkanes and alkenes (excl. F-Gases)** | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| **Polyfluoroalkane sulfonamido derivatives** | | | | | | | | | | | | | | x | | | | x | x | x | | x | | | x | x | x | x |
| **Saturated linear side chains** | | | | | | | | | | | | | | x | x | x | | | | | | | | x | | | | |
| **Side chain fluorinated polymers** | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| **Siloxanes** | | | | x | | | | | | | | | | x | x | | | | | | | | | x | | | | |
| **Sulfonamides** | | | | | | | | | | | | | | | x | | | | | | | | | x | | | | |
| **Sulfonic acids** | | | | | | | | | | | | | | | x | | | | | | x | | | x | | | | |
| **Sulfonyl amides** | | | | | | | | | | | | | | | x | | | | | | | | | x | | | | |
| **Sulfonyl halides** | | | | | | | | | | | | | | | x | | | | | | | | | x | | | | |
| **Unsaturated linear side chains** | | | | | | x | | | | | | | | x | x | x | | | | | | | | x | | | | |

It has been suggested that due to the vast number of PFAS on the global market, grouping strategies are needed to reduce the time and resources required to evaluate these substances and to streamline the regulatory process. Cousins *et al.* propose two possible approaches for grouping PFAS, one being a strategy based on their intrinsic properties (e.g. persistence, bioaccumulation potential, toxicity, mobility, molecular size) and the other being a strategy that informs risk assessment through estimation of cumulative exposure and/or effects[33].

The definition of PFAS used by the OECD and the Dossier Submitters is very broad and it must be acknowledged that it encompasses a range of different substances with large variation between their hazard and emission profiles.

## 3.2 POLICY CONTEXT

Certain PFAS are currently regulated in the EU and internationally, which includes some PFCAs, PFOA, and PFOS, while several other PFAS are being considered for future regulation (see Table 3-2).

Table 3-2 Current regulation of PFAS

| | Precursor Lists | | | Regulatory Lists | | | |
|---|---|---|---|---|---|---|---|
| Substance ↓ | Candidate List | REACH Registry of Restriction Intentions | Stockholm Convention – Proposed for Listing | REACH Annex XVII | POPs Regulation | Stockholm Convention – Annex A | Stockholm Convention – Annex B |
| Jurisdiction→ | EU | EU | Global | EU | EU | Global | Global |
| PFNA* | X | X | X | X | | | |
| PFDA* | X | X | X | X | | | |
| PFUnA* | X | X | X | X | | | |
| PFDoA* | X | X | X | X | | | |
| PFTrDA* | X | X | X | X | | | |
| PFTDA* | X | X | | X | | | |
| PFTA | | | X | | | | |
| PFPeDA | | | X | | | | |
| PFHxDA | | | X | | | | |
| PFHpDA | | | X | | | | |
| PFODA | | | X | | | | |
| 133921-38-7 | | | X | | | | |
| 68310-12-3 | | | X | | | | |
| PFBS | X | | | | | | |
| HFPO-DA | X | | | | | | |
| PFOA | X | | | | X | X | |
| PFOS | | | | | X | | X |
| PFHxS | X | X | X | | X | | |
| PFHxA | | X | X | | | | |

The following sub-sections provide a summary of the regulatory actions under selected policies from Table 3-2.

### 3.2.1 Stockholm Convention on Persistent Organic Pollutants

The Stockholm Convention is an international treaty to protect human health and the environment from the harmful effects of Persistent Organic Pollutants (POPs). POPs are organic chemical substances with persistent

[33] Cousins et al. (2020). Strategies for grouping per- and polyfluoroalkyl substances (PFAS) to protect human and environmental health. *Environ. Sci.: Processes Impacts*, 22, 1444-1460. Available at: https://pubs.rsc.org/en/content/articlehtml/2020/em/d0em00147c

and bioaccumulative properties and are also toxic to humans and the environment. The inclusion of a substance in Annex A prohibits its production and use, while a listing in Annex B restricts its production and use to certain conditions. PFOA, its salts, and related compounds are included in Annex A but there are specific exemptions for certain uses[34]. PFOS is listed in Annex B and also have a number of specific exemptions and acceptable uses[35].

PFHxS is listed under Annex A of the Stockholm Convention and therefore is prohibited under the POPs Regulation ((EU) 2019/1021)[36]. PFHxS is also currently being assessed for a restriction under REACH[37] (see below). In the final Committee for Risk Assessment (RAC)/ Committee for Socio-economic Analysis (SEAC) opinion on the proposed restriction, it is noted that while the POPs Review Committee had recommended PFHxS, its salt, and related compounds for addition to Annex A of the Stockholm Convention, the proposed REACH restriction is considered to contribute to this discussion and the future update of the EU POPs Regulation. Therefore, the current proposal is coherent with those activities on PFHxS by the POPs Review Committee[38].

### 3.2.2 Regulation (EU) 2019/1021 on persistent organic pollutants (POPs Regulation)[39]

The POPs Regulation obliges producers and holders of waste to undertake all reasonable and feasible efforts to ensure their waste is not contaminated with substances listed in Annex IV. Annex IV sets concentration limits for listed substances in waste, and waste containing Annex IV substances above these limits should be disposed of or recovered without delay in a way that ensures the POP content is destroyed or irreversibly transformed. The remaining waste and releases must not exhibit the characteristics of POPs. The disposal and recovery methods that are allowed are listed in Part 1 of Annex V and include:

- physico-chemical treatment
- incineration on land
- use of a fuel to generate energy
- recycling/reclamation of metals and metal compounds.

Regulation (EU) 2020/784 amended Annex I of the POPs Regulation to list **PFOA, its salts and PFOA-related compounds** from the 4 July 2020. Under Annex I, PFOA and its salts are prohibited in substances, mixtures, or articles above 0.025 mg/kg (25ppb), and individual or a combination of PFOA-related substances are prohibited above 1 mg/kg. Companies previously using PFOA, its salts, or related compounds have had to take measures to eliminate their use or find substitutes for their products. Time limited exemptions have been granted for certain uses until the specified dates (see Appendix 1).

Annex I of the POPs Regulation also prohibits **PFOS and its derivatives in substances or mixtures** in concentrations above 10 mg/kg (0.001%), or in articles, semi-finished products, or parts in concentrations above 0.1% and 1 µg/m$^2$ of coating materials. Exemptions from the ban are granted for the following purposes and uses:

- mist suppressants for non-decorative hard chromium (VI) plating in closed loop systems[40]
- articles already in use before 25 August 2010 containing PFOS are exempt.

[34] The Conference of the Parties (2012). SC-9/12: Listing of perfluorooctanoic acid (PFOA), its salts and PFOA-related compounds. Available at: http://chm.pops.int/Portals/0/download.aspx?d=UNEP-POPS-COP.9-SC-9-12.English.pdf

[35] The Conference of the Parties (2017). SC-4/17: Listing of perfluorooctane sulfonic acid, its salts and perfluorooctane sulfonyl fluoride. Available at: http://chm.pops.int/Portals/0/download.aspx?d=UNEP-POPS-COP.4-SC-4-17.English.pdf

[36] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.LI.2020.188.01.0001.01.ENG&toc=OJ:L:2020:188I:TOC

[37] ECHA (2018). Registry of restriction intentions until outcome - Perfluorohexane-1-sulphonic acid, its salts and related substances. Available at: https://echa.europa.eu/registry-of-restriction-intentions/-/dislist/details/0b0236e1827f87da

[38] RAC/SEAC (2020). Opinion on an Annex XV dossier proposing restrictions on PFHxS including its salts and related substances. Available at: https://echa.europa.eu/documents/10162/fdaed5b0-b6e4-9a21-b45d-ca607c05f845

[39] https://echa.europa.eu/pops-legislation

[40] Installations producing or using PFOS for this purpose must using BATs and should only carry on if safer alternatives are not economically or technically feasible.

### 3.2.3 Regulation (EC) No. 1907/2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)[41]

As shown in Table 3-2, certain PFAS are restricted under REACH or proposed for restriction under REACH, or on the Candidate List. Below is a summary of the conditions of the current restrictions and proposed restrictions.

One of the precursor substance lists to regulation, is the Candidate List of Substances of Very High Concern (SVHCs) for Authorisation. A number of PFAS are included on the Candidate List, with the majority being listed based on their persistent, bioaccumulative and toxic (PBT) properties. **PFBS and its salts**[42], and **HPFO-DA, its salts and its acyl halides**[43] are both listed as SVHCs on the Candidate list for an equivalent level of concern having probable serious effects to human health and the environment (Article 57(f)) because of their persistent, mobile, and toxic properties. This means that producers and importers of articles containing PFBS or HPFO-DA have to notify to ECHA if both the following conditions are met:

- PFBS or HPFO-DA is present in their articles above a concentration of 0.1% weight by weight.
- PFBS or HPFO-DA is present in these articles in quantities greater than one tonne per year.

The addition of various Perfluorocarboxylic acids (PFCAs) on the Candidate List has since led to a restriction under REACH Annex XVII (Entry 68). Entry 68 prohibits C9-C14 PFCAs, their salts, and related substances from being manufactured or placed on the market as substances on their own from 25 February 2023. They are also prohibited from being used as a constituent in another substance, in a mixture, or in an article if their concentration is 25 ppb or more for the sum of C9-C14 PFCAs and their salts, or 260 ppb or more for the sum of C9-C14 PFCA-related substances.

The restriction sets a number of derogations by way of delayed implementation timelines and higher concentration limits for specific uses of PFCAs. These are summarised in Appendix 1. However, according to ECHA[44] all known uses of PFCAs are historical uses as no current intentional use has been reported by industry in Europe.

Under REACH, there are several restriction proposals that have been submitted and are at various stages along the regulatory process. **Perfluorohexanoic acid (PFHxA), its salts, and related substances** are currently being assessed for a restriction under REACH[45] and have had the opinions from RAC and SEAC adopted. There is also a proposed restriction for PFHxS which intends to restrict the manufacture, use and placing on the market of **PFHxS, its salts and related substances** as substances, constituents of other substances, mixtures, and articles, and for which opinions have been adopted[46].

There are currently two restriction proposals that target **all PFAS**. The first is a proposed restriction on the use of PFAS in fire-fighting foams[47], which, as of May 2023, is progressing through the final stage of opinion development. The aim of the restriction is to prevent further groundwater and soil contamination and the subsequent health risks for people and the environment. Fire-fighting foams have been responsible for a large number of cases of environmental contamination in the EU at sites where they are used, such as airports, military sites and fire training grounds. A grouping approach has been included in this restriction to avoid further cases of regrettable substitution, it has been recognised that there are vast number of PFAS on the market and new substances being designed, therefore a substance-by-substance approach would not be effective or efficient.

The second proposed restriction was prepared by four Member States (Netherlands, Germany, Denmark, and Sweden) and Norway. This joint restriction proposal would see an EEA-wide ban on all manufacture, import

[41] https://echa.europa.eu/regulations/reach/legislation

[42] ECHA (2020). Candidate List of substances of very high concern for Authorisation - Perfluorobutane sulfonic acid (PFBS) and its salts. Available at: https://echa.europa.eu/candidate-list-table/-/dislist/details/0b0236e183da8013

[43] ECHA (2019). Candidate List of substances of very high concern for Authorisation - 2,3,3,3-tetrafluoro-2-(heptafluoropropoxy)propionic acid, its salts and its acyl halides. Available at: https://echa.europa.eu/candidate-list-table/-/dislist/details/0b0236e1833efc3e

[44] ECHA (2018). Background document to the Opinion on the Annex XV dossier proposing restrictions on C9-C14 PFCAs including their salts and precursors. Available at: https://echa.europa.eu/documents/10162/02d5672d-9123-8a8c-5898-ac68f81e5a72

[45] ECHA (2018). Registry of restriction intentions until outcome - undecafluorohexanoic acid (PFHxA), its salts and related substances. Available at: https://echa.europa.eu/registry-of-restriction-intentions/-/dislist/details/0b0236e18323a25d

[46] ECHA (2018). Registry of restriction intentions until outcome - Perfluorohexane-1-sulphonic acid, its salts and related substances. Available at: https://echa.europa.eu/registry-of-restriction-intentions/-/dislist/details/0b0236e1827f87da

[47] ECHA (2022). Annex XV Restriction Report – Proposal for a Restriction: Per- and polyfluoroalkyl substances (PFAS) in firefighting foams. Available at: https://echa.europa.eu/documents/10162/4524f49c-ae14-b01b-71d2-ac3fa916c4e9

and use of PFAS, this was submitted to ECHA in January 2023. The restriction itself is expected to enter into force beyond the 2025 timeframe that was originally planned[48]. ECHA predicts the opinions of the Committee for Risk Assessment (RAC) and Committee for Socio-Economic Analysis (SEAC) to be ready by mid-2024[49], after which the restriction proposal will be taken forward by the Commission for discussion with Member States at the REACH Committee.

This restriction proposal has a broad scope and covers the manufacture, placing on the market, and use of all PFAS which meet the definition[50].

A summary of specific PFAS uses that are restricted under EU legislation (REACH and POPs Regulation) is provided in the table below.

Table 3-3 Uses of PFAS currently regulated in the EU.

| Use | PFCAs | PFOA | PFOS |
|---|---|---|---|
| Oil and water repellence of textiles | **T** | **T** | |
| Manufacture of PTFE and PVDF | **T** | **T** | |
| Semiconductors | **T** | | |
| Photolithography or etch processes in semiconductor manufacturing | **T** | **T** | |
| Photographic coatings applied to films | **T** | **T** | |
| Medical devices | **T** | **T** | |
| Fire-fighting foam | **T** | **T** | |
| Pressurised dose-metered inhalers | **T** | | |
| Fluoroplastics and fluoroelastomers | **T ; L** | | |
| PTFE micro powders | **L** | **L** | |
| Production of pharmaceutical products | | **E** | |
| Transport isolated intermediate | | **L** | |
| Mist suppressants for non-decorative hard chromium (VI) plating in closed loop systems | | | **E** |
| Articles already on the market | **E** | **E** | |

T = Timeframe derogation

L = Concentration limit derogation

E = Exemption without timeframe or concentration limit

### 3.2.4 Regulation (EC) No 1107/2009 concerning the placing of plant protection products on the market (PPPR)[51]

The PPPR set the requirements for plant protection products (PPP), and active substances, safeners, and synergists in PPPs, that are placed on the market in the EU. Under the Regulation (point 3.7.2 of Annex II), active substances, safeners, or synergists cannot be approved for use if they meet PBT/vPvB criteria. This means that any PFAS that meet this criteria are prohibited from use in PPPs.

[48] Chemical Watch (2022). EU PFAS restriction proposal will not incorporate 'essential use'. Available at: https://chemicalwatch.com/447571/eu-pfas-restriction-proposal-will-not-incorporate-essential-use#utm_campaign=443545&utm_medium=email&utm_source=alert

[49] Chemical Watch (2022). Delay in PFAS restriction proposal could push back EU-wide ban. Available at: https://chemicalwatch.com/437442/delay-in-pfas-restriction-proposal-could-push-back-eu-wide-ban

[50] ECHA (2021). Registry of restriction intentions until outcome - Per- and polyfluoroalkyl substances (PFAS). Available at: https://echa.europa.eu/registry-of-restriction-intentions/-/dislist/details/0b0236e18663449b

[51] *Regulation (EC) No 1107/2009 of the European Parliament and of the Council of 21 October 2009 concerning the placing of plant protection products on the market and repealing Council Directives 79/117/EEC and 91/414/EEC.* The Official Journal of the European Union. Available from: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02009R1107-20210327

### 3.2.5 Regulation (EU) No 528/2012 concerning the making available on the market and use of biocidal products (BPR)[52]

Article 5(1) and Article 19(4) of the BPR prohibit the use of active substances (Art. 5(1)) or other substances (in the biocidal product, or generated by – Art. 19) which that meet the criteria for PBT, vPvB (amongst other classifications). Certain PFAS will fulfil the definition of being a PBT, or vPvB, and therefore are banned from use in biocidal products. Documented use of PFAS in biocides include[53]:

- PFPAs and PFPiAs as anti-foaming agents in solutions
- EtFOSA (sulfluramid) in ant and termite baits
- Inert enhancing ingredients in pesticides.

## 3.3 CURRENT REGULATORY ACTIONS TO MINIMISE EXPOSURE TO PFAS

Certain PFAS are also regulated, or in the process of being regulated, under water and food legislations. The revised Drinking Water Directive, which entered into force on 12 January 2021, requires Member States to ensure that water intended for human consumption complies with value limits set for "PFAS Total" and "Sum of PFAS", which are currently 0.5 and 0.1 µg/l respectively. Total PFAS means the totality of per- and polyfluoroalkyl substances, while Sum of PFAS means the sum of 20 per- and polyfluoroalkyl substances considered a concern as regards water intended for human consumption listed in point 3 of Part B of Annex III.

In 2014, the first review of the Groundwater Directive (2006/118/EC)[54] Annexes led to the formation of a voluntary Ground Water Watch List (GWWL), the purpose of which is to obtain information on additional substances posing a potential risk (emerging pollutants) in groundwater and for which groundwater quality standards or threshold values should be set. The list ranks substances based on their leaching potential, hazard potential, and currently available monitoring data. Of the top 30 substances, 12 were PFAS and 18 were pharmaceuticals, while the 15 top ranked substances included 6 PFAS[55]. Depending on availability of data and suitable analytical methods, these additional PFAS could be included in the Watch List. There are 10 PFAS[56] already identified in the Watch List process as posing a risk, for which Annex I and/or Annex II of the Groundwater Directive could be amended for their inclusion[57].

Annex X of the Water Framework Directive (WFD, Directive 2000/60/EC[58]) lists chemicals that are of concern in surface waters. This includes two classes: priority substances (for which emissions need to be progressively reduced) and the subset of priority hazardous substances (for which emissions should also cease). The Directive (2008/105/EC) on Environmental Quality Standards (EQS)[59] sets the quality standards to be achieved for each chemical of concern in surface water bodies. Currently, only total PFAS is listed in Annex X and has an EQS in biota based on risk to human health from consuming fishery products.

The Commission staff Working Document (SWD) on PFAS, states that when an analytical method is available, "PFAS total" could be listed in the WFD and an EQS could be set. Specific PFAS identified as SVHCs (e.g, PBT, vPvB, substances of equivalent level of concern) and key PFAS often found in the environment could consequently then be identified as priority hazardous substances[25].

Other EU legislation aimed at addressing exposure across various parts of a product's lifecycle do not currently set any specific provisions for the majority of PFAS, and those that do only address PFOA or PFOS. For

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[52] *Regulation (EU) No 528/2012 of the European Parliament and of the Council of 22 May 2012 concerning the making available on the market and use of biocidal products.* The Official Journal of the European Union. Available from: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02012R0528-20210610

[53] ITRC (2021). PFAS – Per- and polyfluoroalkyl Substance – PFAS Uses. Available at: https://pfas-1.itrcweb.org/2-5-pfas-uses/

[54] Directive 2006/118/EC of the European Parliament and of the Council of 12 December 2006 on the protection of groundwater against pollution and deterioration. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02006L0118-20140711&qid=1689772283272

[55] Voluntary Groundwater Watch List v. 3.1 – June 2019. Available at: https://circabc.europa.eu/sd/a/e6882891-d4a2-4a64-9cf7-f04e13b0d17e/Voluntary%20Groundwater%20Watch%20List%20(Endorsed%20V3.1%20-%20June%202019).pdf

[56] PFBS, PFHxS, PFOS, PFBA, PFPA, PFHxA, PFHpA, PFOA, PFNA, PFDA.

[57] COM (2020) SWD: Poly- and Perfluoroalkyl Substances (PFAS). Available at: https://ec.europa.eu/environment/pdf/chemicals/2020/10/SWD_PFAS.pdf

[58] Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, (2014) The Official Journal of the European Union. Available from: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32000L0060

[59] Directive 2008/105/EC of the European Parliament and of the Council of 16 December 2008 on environmental quality standards in the field of water policy, amending and subsequently repealing Council Directives 82/176/EEC, 83/513/EEC, 84/156/EEC, 84/491/EEC, 86/280/EEC and amending Directive 2000/60/EC of the European Parliament and of the Council, (2013) The Official Journal of the European Union. Available from: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32008L0105https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32008L0105

example, Directive 2010/75/EU on Industrial Emissions (IED)[60] ensures that best available techniques (BAT) are applied by waste treatment plants. PFOA and PFOS are addressed by the BAT Conclusions for monitoring of emissions to waste, which triggers obligations in permits that are given to waste treatment plants.

[60] Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control) Text with EEA relevance (recast) (2011) The Official Journal of the European Union. Available from: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32010L0075

# 4. PROPOSED REACH RESTRICTION OF PFAS

This section provides an overview of the policy options carried forward for analysis in this Study and the assumptions used in the analysis. It is structured as follows:

- **Section 4.1** – Policy Options for assessment
- **Section 4.2** – Assumptions for analysis

## 4.1 POLICY OPTIONS FOR ASSESSMENT

This study considers the economic impacts of the proposed REACH restriction on the manufacture, placing on the market and use of PFAS[61].

Box 1 PFAS in the scope of the proposed restriction of PFAS

*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).*

*A substance that only contains the following structural elements is excluded from the scope of the proposed restriction: CF3-X or X-CF2-X', where X = -OR or -NRR' and X' = methyl (-CH3), methylene (-CH2-), an aromatic group, a carbonyl group (-C(O)-), -OR'', -SR'' or –NR''R''', and where R/R'/R''/R''' is a hydrogen (-H), methyl (-CH3), methylene (-CH2-), an aromatic group or a carbonyl group (-C(O)-).*

The REACH restriction proposal (Annex XV report) was submitted to ECHA in January 2023 and published on the ECHA website on 7th February 2023. The consultation on the Annex XV report opened on 22 March 2023 and shall run until 25 September 2023.

The Annex XV report contains two restriction options (RO):

- RO1 – full ban with no derogations and a transition period of 18 months;
- RO2 – full ban with use-specific time-limited derogations (18 month transition period plus either a five or 12 year derogation period) and time-unlimited derogations for *inter alia* active substances in plant protection products (PPP), biocidal products (BP) and human and veterinary medicinal products (MP).

The Dossier submitters concluded that although both restriction options are proportionate to the risk, RO2 is the most balanced option as it allows for the mitigation of unwanted effects on society linked to the lack of availability of products for which alternatives are not currently available.[62]

## 4.2 ASSUMPTIONS FOR ANALYSIS

This section presents the assumptions that have been developed by the study team and Cefic to allow for the ex-ante assessment of business impacts. These assumptions are based on literature review of publicly available information.

**Assumption 1 - Timeline**

The timeline used in the assessment of impacts assumes that the proposed PFAS restriction would enter into force in 2025. The analysis of impacts was conducted over a 15-year timeframe (i.e. up to 2040-2042) as it was assumed that investments into the development of PFAS alternatives would occur primarily over this period.

[61] Ibid footnote 8

[62] ECHA (2023) Annex XV Restriction Report. Proposal for a restriction of Per- and polyfluoroalkyl substances (PFASs). Available at: https://echa.europa.eu/registry-of-restriction-intentions/-/dislist/details/0b0236e18663449b

**Assumption 2 – Scope of restriction scenarios**

Three variations in the scope of the restriction were used in the analysis. The first restriction scenario is aligned with RO1 in the restriction proposal and is a full ban on the manufacture, placing on the market and use of PFAS in the EEA.

The second restriction scenario has been aligned with RO2 from the restriction proposal and includes three types of derogation[63]:

- 6.5 years after entry into force (*sufficiently strong evidence that technically and economically feasible alternatives are not yet available but potential alternatives are in development, or where known alternatives are available but not on the market in sufficient quantities)*,
- 13.5 years after entry into force (*sufficiently strong evidence that technically and economically feasible alternatives are not yet available and potential alternatives are unlikely to become available in the near future, or where certification or regulatory approval of PFAS-free alternatives cannot be achieved within a five-year derogation period)*, and
- time-unlimited derogations for plant protection products, biocidal products and human and veterinary medicinal products, PFAS used in calibration of measurement instruments and as analytical reference materials, refrigerants in HVACR-equipment in buildings where national safety standards and building codes prohibit the use of alternatives.[64]

The conditions of the proposed restriction state that derogations may be proposed by the Dossier Submitter, or by the relevant stakeholders during the consultation process with an accompanying risk and socio-economic risk justification[65].

The third restriction scenario is based on a more limited scope for derogation, lying between restriction scenario 1 and restriction scenario 2.

[63] Ibid footnote 62

[64] Ibid footnote 62

[65] Ibid. footnote 8

# 5. BASELINE

This section summarises the most important economic statistics for the manufacture, placing on the market and use of PFAS in the EEA and provides an overview of the industry's current state and trends. For selected economic indicators, baseline forecasts are offered, which will be used as a guide throughout the examination of business impacts in Section 6. Historical data at the EEA level for the sectors in scope has been used to generate these baseline projections.

## 5.1 SECTORAL SCOPE

PFAS are chemicals that can be used in polymeric or non-polymeric forms. Since they are manufactured in different and many subareas of the chemicals sector, the scope of chemical industry that is going to be used as reference for trends and projections of the sample of PFAS manufacturers and importers throughout this document, which corresponds to NACE Rev. 2 Class C20, defined as follows:

> "*This division includes the transformation of organic and inorganic raw materials by a chemical process and the formation of products. It distinguishes the production of basic chemicals that constitute the first industry group from the production of intermediate and end products produced by further processing of basic chemicals that make up the remaining industry classes*."

PFAS are widely used across a variety of sectors and applications such as medical, aerospace, packaging, automotive, construction, and electrical appliances sectors (see Section 3.1). In order to encompass the breadth of downstream user applications and sectors, the following NACE Rev. 2 classes are used as reference for baseline trends and projections in each of those using sectors: A01, A02, C13, C14, C15, C19, C20, C21, C22, C26, C27, C28, C29, C30, D32, D35, E36, E37, F41, H49, H50, H51, M72, and R91; additionally, subdivisions of C20.59 from PRODCOM (PRODuction COMmunautaire, Eurostat) at the level of product for lubricants.

## 5.2 HISTORICAL TRENDS AND BASELINE PROJECTIONS

Economic statistics specific to the production and import of PFAS are not publicly available. As stated above, this industry is not contained in its own defined NACE code, but rather its activity spreads across the whole chemicals sector, corresponding to NACE Rev. 2 Class C20. The number of companies that produce PFAS or their overall production volume or turnover associated to PFAS are also unknown. Therefore, the baseline economic and business figures for PFAS manufacturers and importers in the following section have been gathered from the stakeholder consultation, and **correspond only to the sample** that was gathered for this Study. Additionally, data gathered for the Impact Assessment of the PFAS Restriction and published in Annex E[66] of the Restriction Report has been used to contrast our survey respondents' expectations with the wider sector's trends.

Downstream users in this study are companies sitting in 30 different downstream application sectors that use PFAS in their mixtures and articles or in equipment that is used to manufacture the products they sell, such as sealing devices. In order to form a future business baseline, the estimated growth trends of each sector as defined by their past history, for each of their assessed business measures, were applied to the aggregate business measures of each sector as defined by the sample of survey participants.

In conclusion, **both in the case of PFAS manufacturers and importers, and PFAS downstream users, the actual sector sizes (e.g., number of firms, production volume, turnover, and level of employment) should be taken as lower bounds (i.e., there may be more firms and more production volume than collected in our sample), as they could and are assumed to be larger than the sample that participated in this study.** Representativeness of each of the samples is discussed in the subsections below.

### 5.2.1 Manufacturers and Importers of PFAS

A total of 13 EEA PFAS manufacturers and importers were surveyed to gather evidence of the sector's market size and business measures. These are considered to be broadly representative of the PFAS manufacturing and importing sector; however, it has not been possible to confirm the proportion of the market captured by

[66] ECHA (2023) Annex E to the Annex XV Restriction Report. Available at: https://echa.europa.eu/registry-of-restriction-intentions/-/dislist/details/0b0236e18663449b

these respondents. For example, at the time of writing, Cefic's sector group of FluoroProducts and PFAS for Europe (FPP4EU) is formed of 14 companies, of which, as reported by Cefic, only 8 are manufacturers, the remaining being users of PFAS[67].

Surveyed PFAS manufacturers and importers do not limit their activities to the manufacture and import of PFAS; close to half of the sample report having a wider business scope and turnover from other types of products. For example, their total turnover was reported to be €13.0 billion in 2021, and they employed around 33,700 people in the EEA. Of these, it is estimated that around 10,000 employees are dedicated to PFAS business lines. In 2021, these companies produced and imported PFAS in the EEA market with a turnover value around €3.2 billion. 77% of this was reportedly attributed to sales of polymeric PFAS, while 23% would come from the sales of non-polymeric PFAS. The sector's Gross Value Added (GVA) to the European economy (i.e., its direct contribution to Gross Domestic Product (GDP)) was estimated to be €1.3 billion, or 40% of their turnover.

Survey participants were asked about their expectations of growth in the long term over the next 10 years in a baseline scenario with no restriction of PFAS. On average, a Compound Annual Growth Rate (CAGR[68]) of 4.9% is estimated for turnover from PFAS, largely driven by polymeric PFAS. Similarly, the PFAS manufacturing sector's Gross Value Added is estimated to increase by a CAGR of 5.2%.

If no more regulatory action is taken, these key trends are projected to persist in the following decades. This is the baseline or "counterfactual" scenario, which is a hypothetical situation in which the proposed restriction is not implemented. For six indicators or themes, these baseline scenario projections and trends are taken as reference:

- Turnover
- Gross Value Added
- Intermediate consumption and operating costs
- Capital expenditure
- Research and Development
- Employment

Each of these seven indicators is considered in turn in the following subsections. All baseline projections are estimated based on the survey to EEA PFAS manufacturers and importers and on public data at the level of the EU chemicals sector.

#### *5.2.1.1 Turnover of EEA PFAS manufacturers and importers*

Figure 5-1 shows how the turnover related to PFAS manufacturing and import in the EEA is estimated to grow at a CAGR of 4.9% over the next 20 years, considering PFAS as a whole (polymeric + non-polymeric). This estimate is based on the views of the PFAS manufacturers and importers consulted for this Study. It is broadly in line with the growth reported in the PFAS Restriction Report Annex E[69], whereby a 4-4.5% growth of fluoroplastic consumption is reportedly estimated, and a global growth rate of 5.6% for PTFE alone is suggested between 2020 and 2027[70]. In real terms, this results in a CAGR of 3.2% over the 2021-2042 period, and a cumulative growth of 93%, shown in the Figure below.

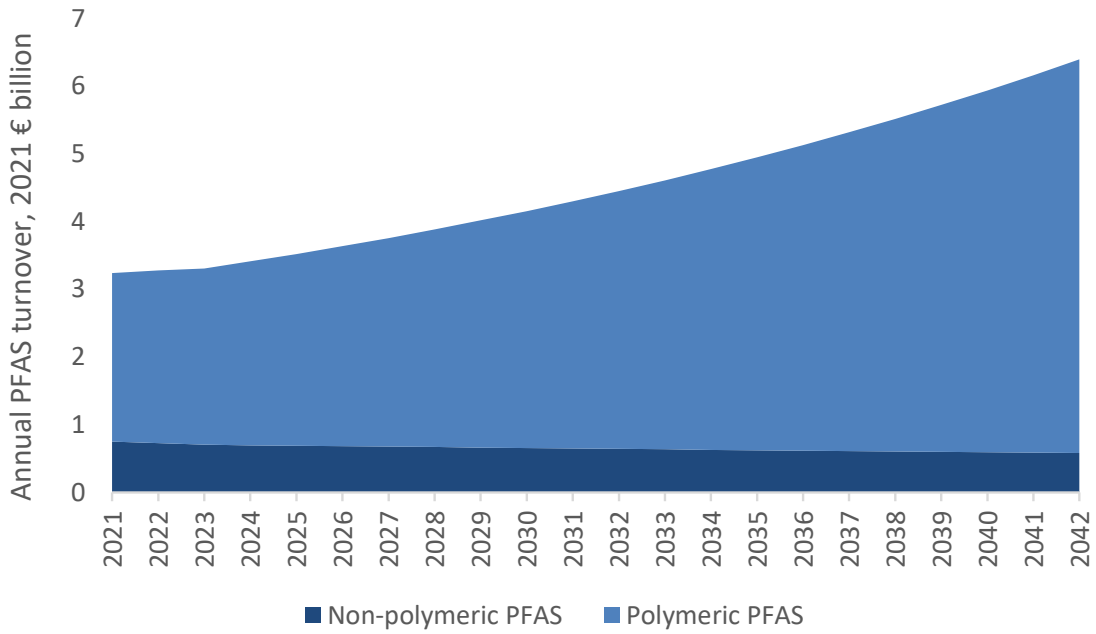
[67] FPP4EU (2023) https://www.fpp4eu.eu/about-us/who-we-are/

[68] A Compound Annual Growth Rate represents the constant annual growth that a variable $x$ would have between two separate points in time (0 and T), taking into account that growth cumulates over time, e.g., that the value of $x$ in year 0 would be $x_0$, in year 1 would be $x_0$*(1+CAGR), in year 2 would be $x_0$*(1+CAGR)$^2$, and so on, until in year T when its value would be $x_0$*(1+CAGR)$^T$.

[69] ECHA (2023). Annex E to the Annex XV Restriction Report - Proposal For A Restriction of Per- and polyfluoroalkyl substances (PFASs). Available at: https://echa.europa.eu/documents/10162/8de11d7c-c56f-e204-5072-e89f11071219

[70] Note: this reference refers to polymeric PFAS only.

Figure 5-1 Turnover from an EEA sample of PFAS manufacturers and importers (€ 2021[71]), 2021 to 2042. Source: Ricardo estimation based on consultation to industry members and data from Eurostat.




As reflected in Figure 5-1, polymeric PFAS are the drivers of this growth, while non-polymeric PFAS, after discounting the effects of inflation, actually slightly decrease over the period.

#### *5.2.1.2 EEA PFAS manufacturers and importers Gross Value Added (GVA)*

GVA directly generated from PFAS manufacturing and importing activities in the sample that participated in the survey, technically defined as the value of output or production minus intermediate consumption of goods and services (gross, i.e., before taxes), refers to the sector's contribution to GDP.

In 2021, the sector's GVA was around €1.3 billion, accounting for around 40% of the sector's total economic output. This, based on the estimated growth of operating costs and production value, is projected as a result to grow at a real CAGR of 3.5% per year on average over the 2021-2042 period.

#### *5.2.1.3 Intermediate consumption, including operating costs of EEA PFAS producers and importers*

The value of the EEA PFAS manufacture/ import sample's demand for "goods and services consumed as inputs by a process of manufacturing" is referred to as "intermediate consumption". This accounts for a large percentage of the industry's operational expenditures, as well as its interconnection with the local (and international) economy and ability to drive activity through the supply chain.

While it is acknowledged that intermediate consumption excludes the costs of personnel and other less significant day-to-day costs, these forecasts provide a proxy for the growth of operational costs. When necessary, this gap has been filled by estimating and adding employment costs to intermediate consumption for a sector-level operational cost estimate.

Overall intermediate consumption is assumed to follow a similar pattern to turnover, according to survey participants, although projected growth is slightly lower than turnover, thus resulting in the growth of gross value added presented above. Ongoing efforts by business, as well as the European and national policy aspirations, such as the European Green Deal, are likely to promote further and significant gains in energy efficiency through to 2050. This shift will be costly in terms of investment needed (Capex), requiring increased operational as well as capital expenditures, but it is predicted to deliver a similar level of growth to the baseline, further lowering operating cost per unit of revenue.

The resulting long term real growth trend is a CAGR of 2.9% for intermediate consumption.

[71] All monetary quantities are isolated from the effects of inflation and expressed in real euros of 2021, as indicated by '€ 2021'.

#### *5.2.1.4 Capital expenditure activity of EEA PFAS manufacturers and importers*

Capital expenditure in the PFAS manufacturing and import sector is estimated to grow strongly, as reported by survey participants, at a real CAGR of 5.0% between 2021-2042.

As conjectured above, it is assumed that recent trends, such as the increased focus on moving faster towards climate neutrality and other demands on the sector, may need a faster increase in the EEA PFAS manufacturing and import sector's capital expenditure.

These estimates are thought to provide a credible baseline against which to evaluate the effects of the policy changes examined in this study. However, these estimations capture the potential trend, which is uncertain, and it is possible that future Capex will show significant volatility, surpassing and dropping below the estimated trend of overall annual increases.

#### *5.2.1.5 Research and Development of EEA PFAS manufacturers and importers*

Future R&D expenditure trends expected by PFAS manufacturers and importers are very similar to those expected for capital expenditure. In real terms, this results in a CAGR of R&D related to PFAS that is estimated to be 3.7% per year.

The R&D expenditure includes only that which is taking place within the EEA. Some chemical businesses invest and/or develop some or all of their R&D efforts outside of the EEA in addition to their expenditure in the EEA. According to the survey of 13 companies manufacturing and importing PFAS, the majority develop at least 50% of their R&D activities in Europe, while those that spend all of their R&D outside the EEA are a minority in number. However, while spending outside of the EEA might have less direct influence on the European economy, the outputs and outcomes of these investments (such as innovation) could still have an impact on the sector's production and value added in the EEA.

#### *5.2.1.6 Employment of EEA PFAS manufacturers and importers*

The chemicals sector as a whole is known for employing highly skilled individuals who are compensated appropriately. The chemicals sector pays amongst the highest wages, second only to petroleum refining and pharmaceuticals.

As the EEA PFAS manufacturing and import sector expands in the future, this will expectedly be accompanied by an increase in labour demand. However, there are some distinctions between the output and employment of the sector:

- Employment has typically been less variable than the chemicals sector’s output or production in the short run. When output declines, for example, employment declines more gradually and with a time lag. The change in employment is likewise likely to take longer than the change in output. This is due to the EEA labour market's relative rigidity as compared to the market for goods and services, which means that production may be modified more simply and quickly than employment.
- In the long run, employment and production are expected to follow similar trends until significant technical and/or manufacturing process changes have a significant impact on this relationship. This is a risk of unknown magnitude that has not been factored into the baseline forecasts.

Based on the expectations on employment growth provided by survey participants for total employment at their companies (employment in just PFAS business lines was not provided and therefore is an extrapolation from the weight of turnover from PFAS), employment is estimated to expand at a CAGR of 1.7% each year on average.

### 5.2.2 PFAS Downstream Users

As already introduced, PFAS downstream users considered in this study are companies that use PFAS in their mixtures and articles. They fall into different NACE Rev. 2 Classes (A01, A02, C13, C14, C15, C19, C20, C21, C22, C26, C27, C28, C29, C30, D32, D35, E36, E37, F41, H49, H50, H51, M72, and R91; additionally, subdivisions of C20.59 from PRODCOM (PRODuction COMmunautaire, Eurostat) at the level of product for lubricants). As such, the figures presented here as baseline refer only to the sample of downstream users that participated in the consultation, and sector-wide numbers remain unknown.

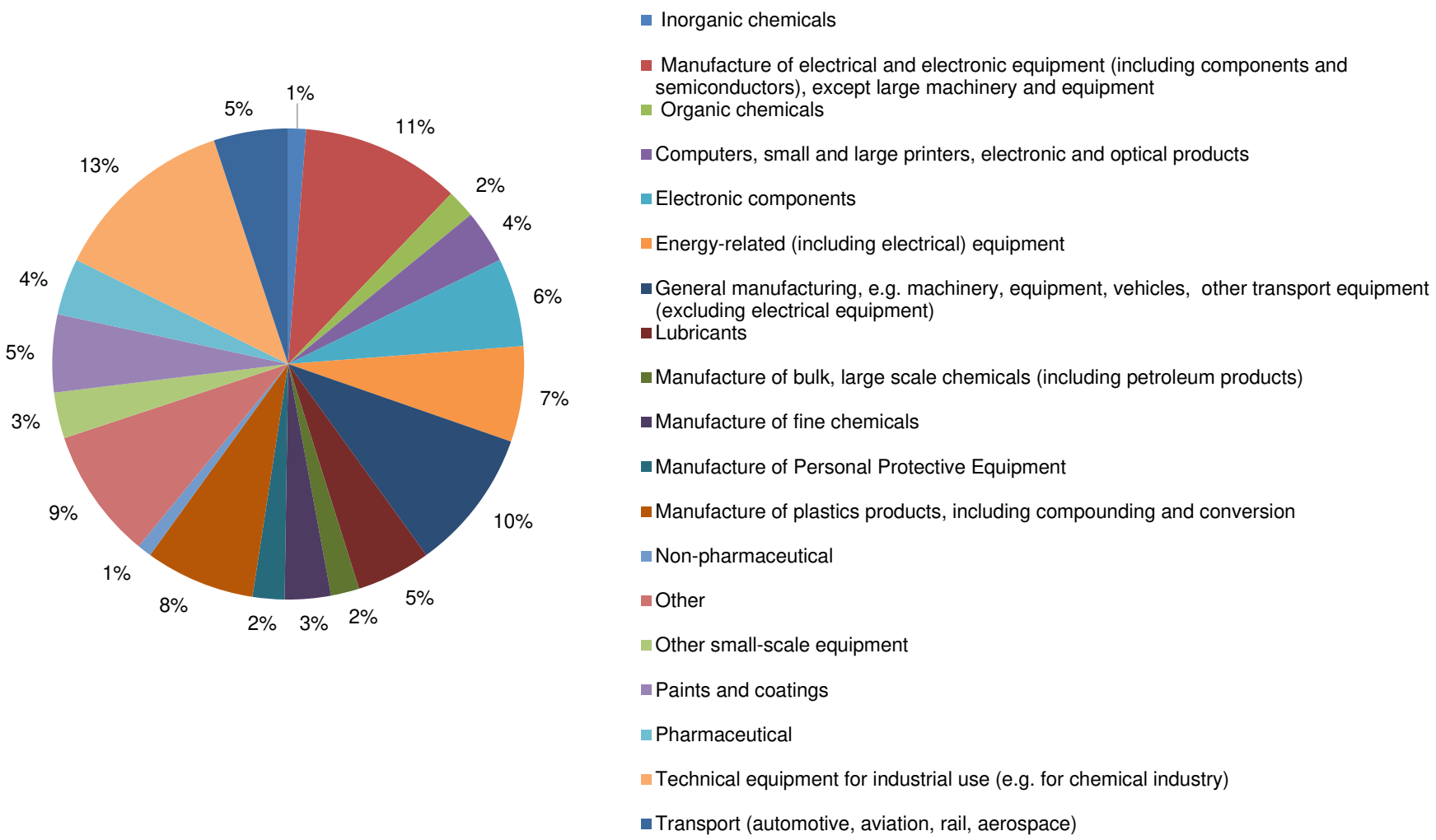
Surveyed PFAS downstream users generate a total turnover of €11,900 billion in 2021 and employ more than 35 million people. Their past growth trends are subsumed in the overall chemicals sector, already commented for PFAS manufacturers and importers.

PFAS downstream users also reported the destination (i.e., applications) of their products containing PFAS. Figure 5-2 below shows how each of the applications is represented in survey responses. It is important to note that many of the 173 survey respondents produce products containing PFAS that are used in more than one application. On average, they manufacture and sell to 3.2 applications each. Sectors have been grouped in order to prevent exposure of confidential business information. The 24% of responses grouped as “other” represent the following sectors:

- Agriculture, forestry, fishery
- Preservation of cultural heritage
- Building and construction work
- Electricity, steam, hydrogen, gas, batteries and fuel cells
- Life Sciences
- Manufacture of textiles, leather, fur
- Medical devices
- Medical equipment
- Research and development
- Scientific research and development
- Water supply, water treatment and sewerage treatment

In the following sections we introduce the baseline scenario projections and trends for the same seven indicators specific case of the sample of PFAS downstream users.

Figure 5-2 Representation of the applications of destination of downstream users' products containing PFAS as reported in consultation.



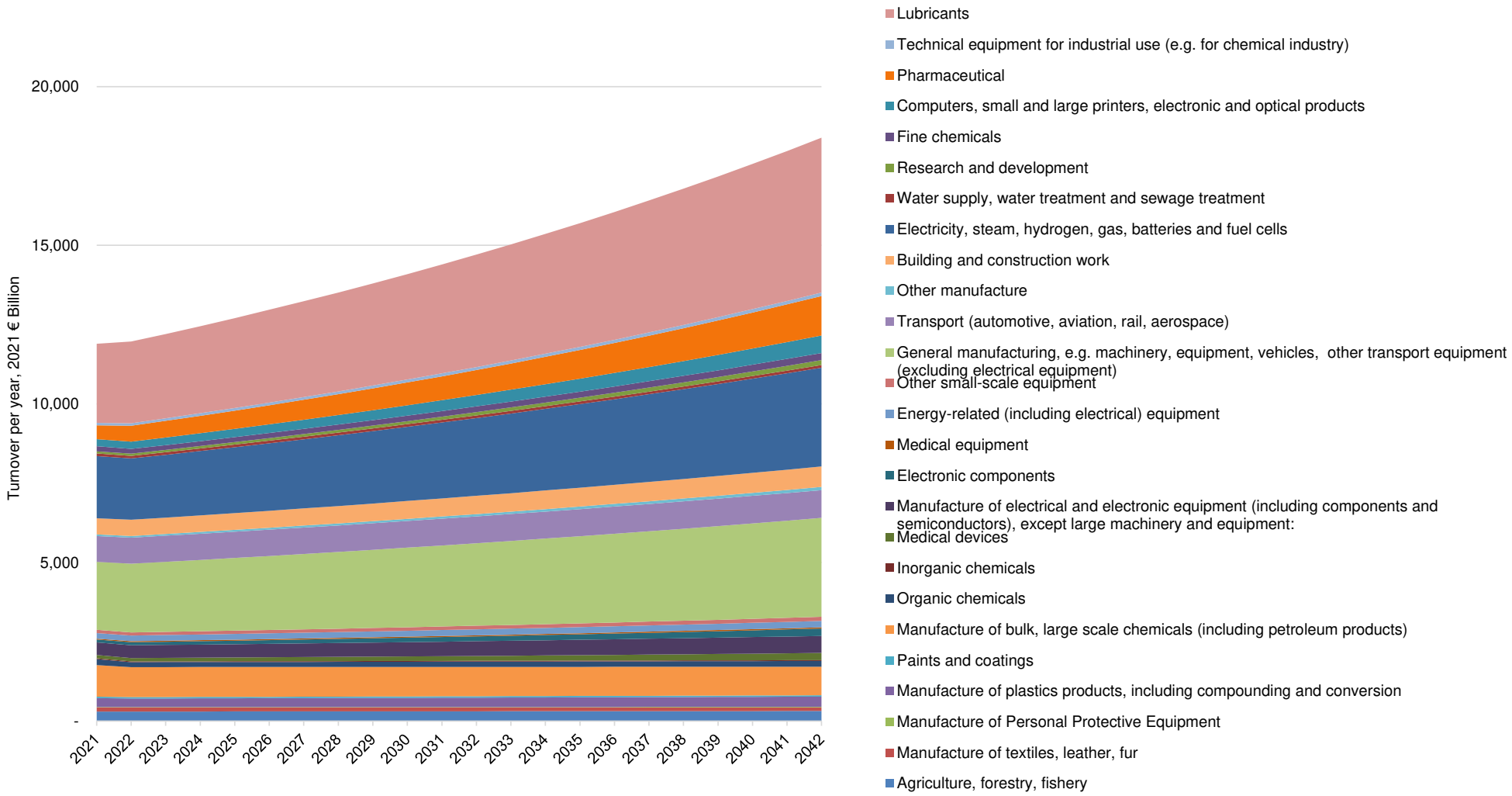
#### *5.2.2.1 Turnover from PFAS downstream users*

The selected sectors of PFAS downstream users generated a total turnover of €11,900 billion in 2021. Their turnover is projected to grow at a real CAGR of 2.8 % over the next 20 years and is depicted in Figure 5-3 below. This estimate is based on the current and expected growth of the European economy, the overall business context and the policy baseline. These projections align with the growth that may be expected from a growing industry, sustained and stable but moderate.

The *General manufacturing, e.g. machinery, equipment, vehicles, other transport equipment (excluding electrical equipment)* sector is estimated to contribute the most to total PFAS downstream users' turnover (23% of total turnover across the period). It is followed by *Electricity, steam, hydrogen, gas, batteries and fuel cells* (22% over the total series). These sectors are estimated to grow at a similar same pace as the total PFAS downstream users' group. Other sectors, however, are projected to grow above the average. These are: *Pharmaceutical, Electronic components, Computers, small and large printers, electronic and optical products, Other manufacture, Research and development, Medical devices*

On the contrary, sectors such as *Manufacture of Personal Protective Equipment, Inorganic chemicals, or Medical Equipment* will only contribute around 0.7% to total PFAS downstream users' 'turnover over the 2021-2042 period and are estimated to have moderate growth rates (CAGR) between 0.1% and 1.1% over the period.

Figure 5-3 Turnover from an EEA sample of PFAS downstream users (€ 2021), 2021 to 2040. Source: Ricardo estimation based on consultation to industry members and data from Eurostat.



#### *5.2.2.2 Gross Value added from PFAS downstream users*

The GVA from the PFAS downstream users' sample amounted to around €2,300 billion in 2021, equivalent to around a third of its turnover. This has increased steadily over the last decade at a CAGR of 2.5%, which is 0.5 percentage points more than sector's turnover growth. In the baseline scenario, these trends are estimated to continue to grow into the future. Starting from a low level, the difference in growth that is expected between production and the cost of inputs may allow GVA to grow at a CAGR of 2.1% over the next 20 years. Most of the sectors are projected to grow at a similar pace, with the exception of *Pharmaceutical, Computers, small and large printers, electronic and optical products, Other manufacture* which might grow at higher CAGR (5.3%, 1.0% and 4.3% respectively) over the 2021-2042 period.

Similarly, to the turnover series, the *General manufacturing, e.g., machinery, equipment, vehicles, other transport equipment (excluding electrical equipment),* and the *Electricity, steam, hydrogen, gas, batteries and fuel cells* might gather most of the GVA across the period, accounting for around a 5% of the series each.

#### *5.2.2.3 Intermediate consumption from PFAS downstream users*

Intermediate consumption of PFAS downstream users was €6,700 billion in 2021, around 71% of their turnover. It has grown at a CAGR of 0.8% over the last decade. Similarly, to the other economic series analysed, intermediate consumption is estimated to grow across the period at a CAGR of 1.7%. Some sectors as the *Pharmaceutical, Electronic components, Medical devices, Other manufacture* might experience higher growth rates and grow between 3.2% and 5% over the 2021-2042 period.

Again, *General manufacturing, e.g., machinery, equipment, vehicles, other transport equipment (excluding electrical equipment)*, and *Electricity, steam, hydrogen, gas, batteries and fuel cells* might be the sectors that most contribute to the intermediate consumption from PFAS downstream users- 17% of total OPEX over the period each.

#### *5.2.2.4 Capital expenditure activity from PFAS downstream users*

Capital expenditure from PFAS downstream users has generally grown in the last decade. The investment based in the EEA has grown at a CAGR of 3% from 2011 to 2021. This growth is higher than the turnover series of the PFAS downstream users over the same period. In 2021, the capital expenditure of the sector was €382 billion. This is greatly driven by the *Electricity, steam, hydrogen, gas, batteries and fuel cells* which gathers more than 30% of the total's capital investment, followed by the *General manufacturing*, and *Transport* sector which account for 15% and 12% of the total's series in 2021.

For the next two decades, the observed growth trend in capital expenditure is estimated to slightly reduce to a CAGR of 2.8% for the 2021-2042 period. Some sectors, such as *Transport* or *Pharmaceutical*, are projected to grow at higher CAGR (around 6%) over the same period, whereas others, such as *Manufacture of bulk, large scale chemicals* or *Building and construction,* are estimated to see much lower growth, at close to 0.

#### *5.2.2.5 Employment from PFAS downstream users*

In 2021, the downstream users of PFAS employed around 35 million persons in the EEA region. Based on historical series, this figure stayed relatively constant and employment from PFAS downstream users grew at a 0.1% CAGR between 2011 and 2021.

For the next two decades, PFAS downstream users' employment is estimated to grow at lower rates than other economic series analysed, including turnover. Employment has a projected CAGR of 0.7% per year in the 2021-2042 period. The *Agriculture, forestry, fishery* sector, followed by the *General manufacturing* and *Transport* sector, will employ most of the labour force. Together they account for more than 55% of the total employment of the PFAS downstream users..

### 5.2.3 Sample's representativeness

As previously discussed, there is limited historical evidence available as a reference for assessing potential costs and benefits following the proposed restriction. Consequently, we have relied on consulting businesses to gather evidence regarding the potential impacts they might experience. It is important to note that the data collected through these consultation exercises is constrained by the sample of respondents and their comprehension and evaluation of how the proposed restriction may affect their operations. As a result, we have conducted a sensitivity analysis by comparing baseline data at the EEA level with the sample's responses

to assess the representativeness of the sample. Table 5-1 below illustrates the percentage of total's EU turnover and production value captured by the sample for each application sector.

Table 5-1 Sample's representativeness

| Application | Turnover (%) |
|---|---|
| Agriculture, forestry, fishery | 0.1% |
| Manufacture of textiles, leather, fur | 0.3% |
| Manufacture of Personal Protective Equipment | 29% |
| Manufacture of plastics products, including compounding and conversion | 17% |
| Paints and coatings | 27% |
| Lubricants | 41% |
| Manufacture of bulk, large scale chemicals (including petroleum products) | 0.3% |
| Organic chemicals | 5% |
| Inorganic chemicals | 41% |
| Manufacture of fine chemicals | 0.1% |
| Pharmaceutical | 5% |
| Medical devices | 4% |
| Manufacture of electrical and electronic equipment (including components and semiconductors), except large machinery and equipment | 5% |
| Electronic components | 14% |
| Computers, small and large printers, electronic and optical products | 12% |
| Medical equipment | 10% |
| Energy-related (including electrical) equipment | 1% |
| Other small-scale equipment | 4% |
| General manufacturing, e.g. machinery, equipment, vehicles, other transport equipment (excluding electrical equipment) | 1% |
| Transport (automotive, aviation, rail, aerospace) | 1% |
| Technical equipment for industrial use (e.g. for chemical industry) | 30% |
| Building and construction work | 0.1% |
| Electricity, steam, hydrogen, gas, batteries and fuel cells | 0.1% |
| Water supply, water treatment and sewage treatment | 2% |
| Research and development | 0.2% |
| Scientific R&D | 0.1% |
| Life Sciences | 1% |
| **Total** | **3%** |

Overall, the consultation surveys capture 3% of the EEA's turnover of PFAS downstream users. However, there is significant variation in sample representativeness across sectors. For instance, sample data for the manufacturing of inorganic chemicals or the production of lubricants is comprehensive, representing approximately 41% of the sector's turnover. On the other hand, there are 15 sectors where the sample data represents less than 5% of the EEA's turnover. Therefore, while the group of businesses consulted is extensive, it does not fully represent all the experiences within each sector. Additionally, there is a lack of understanding regarding the extent to which PFAS products are used by those businesses who did not participate and that could potentially be affected by the proposed restriction. Given these limitations, the impact results presented in the following sections are solely based on **sample** data. Extrapolating these results to encompass all businesses is not currently feasible. However, this analysis highlights that the impacts presented in this report are likely an underestimate of the total impact on all PFAS manufacturers, importers and downstream users.

# 6. BUSINESS IMPACTS OF THE PROPOSED REACH RESTRICTION OF PFAS

This section presents the ex-ante assessment of the proposed REACH restriction of PFAS. This assessment focusses on how manufacturers, importers, and the participating downstream users, in the EEA may be affected by the proposed policy changes and any potential knock-on effects on the wider EEA economy. This Study is, therefore, **considered an assessment focussed on business and business-driven economic impacts.**

Results from this assessment of potential impacts that industry may be facing from the implementation of the restriction proposal are presented. This assessment draws on the counterfactual, or baseline scenario, developed in Section 5, the most recent available data from Eurostat, evidence gathered through the survey of 13 participating PFAS manufacturers and importers and a survey of 173 participating PFAS downstream users, and secondary research. These outputs are structured into the following sub-sections:

- The scope and potential scale of impact, as indicated by the portfolio of products that are likely to be affected by the restriction scenarios considered in this study and a consideration of potential business responses (**Section 6.2.1 for manufacturers/importers** and **Section 6.3 for downstream users**)
- Costs and benefits driven by the impact on participating PFAS manufacturers, importers and downstream users, including impacts on sectoral turnover from exports and Gross Value Added; intermediate consumption and operating costs, capital investment and R&D expenditure; and employment (**Section 6.2.2 - 6.2.66.2 for manufacturers/importers** and **Sections 6.3.1 - 6.3.6 for downstream users**).

The restriction proposal will affect all per- and poly-fluoroalkyl substances. 13 PFAS manufacturers and importers and 173 PFAS downstream users considered the products in their 2021 product portfolio that could be affected, if the proposed restriction was fully adopted with immediate effect (i.e., in 2025). Impacts and business responses are assessed separately for these two groups in the subsections below.

## 6.1 CONDITIONS OF THE RESTRICTION AND OTHER ASSUMPTIONS MADE IN THE ASSESSMENT

The consultations with companies, both manufacturers and importers, and downstream users of PFAS enabled the confirmation of the scope of the portfolio that is likely to be affected by the restriction proposal and the identification of potential business responses.

To assess the net impacts of this policy on the EEA PFAS manufacturers and importers, and participating downstream users, a baseline and three policy scenarios were developed:

- The sectoral **baseline** (2021-2042) was developed by aggregating evidence of turnover and growth expectations elicited in the survey to PFAS manufacturers and importers, and the participating downstream users. This baseline scenario assumes that the proposed restriction of PFAS is not implemented.
- A first policy scenario (**Scenario 1**) considers that the proposed REACH restriction on the manufacturing, placing on the market and use of PFAS is implemented in full and no derogation is applicable. This includes a transition pathway of 1.5 years until effective implementation. The restriction implies an immediate loss of portfolio that is followed by mitigatory strategies by PFAS manufacturers and downstream users, such as substitution, reformulation and other forms of innovation. As products that use PFAS are affected by the proposed restriction, they will need to be redesigned or replaced with new substances, formulas and/or processes.
- A second policy scenario (**Scenario 2**) considers that the proposed REACH restriction on the manufacturing, placing on the market and use of PFAS, is implemented following Restriction Option 2 (the preferred option) as published in the Annex XV report on 7 February 2023. This includes a transition pathway of 1.5 years until effective implementation. The restriction is followed by mitigatory strategies by PFAS manufacturers and downstream users, such as substitution, reformulation and other forms of innovation. As products are affected by the proposed restriction, they will need to be

redesigned or replaced with new substances, formulas and/or processes. Derogations are implemented according to the restriction proposal, with either a 6.5-year derogation or a 13.5-year derogation affecting only certain applications or products within each sector. Once the time-limited derogations cease, affected products could no longer be placed on the market unless they are substituted and/or reformulated.

- A third scenario (**Scenario 3**) considers that the proposed REACH restriction on the manufacturing, placing on the market and use of PFAS is implemented with a more limited scope for derogation than in Scenario 2. This includes a transition pathway of 1.5 years until effective implementation.

Based on the available evidence[72], it has been assumed that companies may need, on average, around 6 years to adjust their operations and place their substitutes and/or reformulated products on the market. It should be noted that the time to market varies considerably between sectors and at product level, which could not be reflected in such granularity in this assessment. If no derogations were granted, this could lead to larger turnover losses earlier on.

The evidence collated from the two surveys was overlayed with an expected reasonable policy implementation timeline. In essence, this step assigns the reductions in the EEA PFAS manufacturing, import and downstream user sector's product portfolio to the moment or moments in which the proposed restriction would enter into force (i.e., first effective implementation, and potential time-limited derogations for some uses). No business response, e.g., substitution, is considered before that time. By the end of the period of assessment (2042), the size of the products in scope of the restriction proposal have been affected by the regulatory change and all potential mitigatory actions have taken place and effects materialised.

Based on these policy scenarios and the available evidence from the bespoke business consultations, Eurostat and secondary research, the net impacts on the EEA sample of PFAS manufacturers and importers, and the EEA sample of PFAS downstream users, plus the potential knock-on effects on the EEA economy were assessed against the baseline scenarios. These are described in the following: Section 6.2 (Costs and benefits to EEA PFAS manufacturers), Section 6.3 (Costs and benefits to downstream users of PFAS), and Section 6.4 (Qualitative considerations of the proposed restriction).

[72] ECHA (2020) *"Impacts of REACH restriction and authorisation on substitution in the EU"*; DOI: 10.2823/39789. and ECHA (2021) *"Costs and benefits of REACH restrictions proposed between 2016-2020"*. DOI: 10.2823/122943

## 6.2 COSTS AND BENEFITS TO EEA PFAS MANUFACTURERS

There is currently no data on the overall PFAS manufacturing and import market within the EEA. Therefore, it is not possible to extrapolate the results from the sample to the total EEA PFAS market. However, the sample is considered to be broadly representative of the PFAS manufacturing and importing sector (see Section 5.2.1 for more detail about how the sample relates to what is known of this market). Therefore, the survey results are reported on their own, as sample statistics.

### 6.2.1 Direct impacts on businesses

This section outlines the extent to which the portfolio of products sold by PFAS manufacturers and importers could be affected in some way, how they might respond to these potential impacts, and what this means for their market.

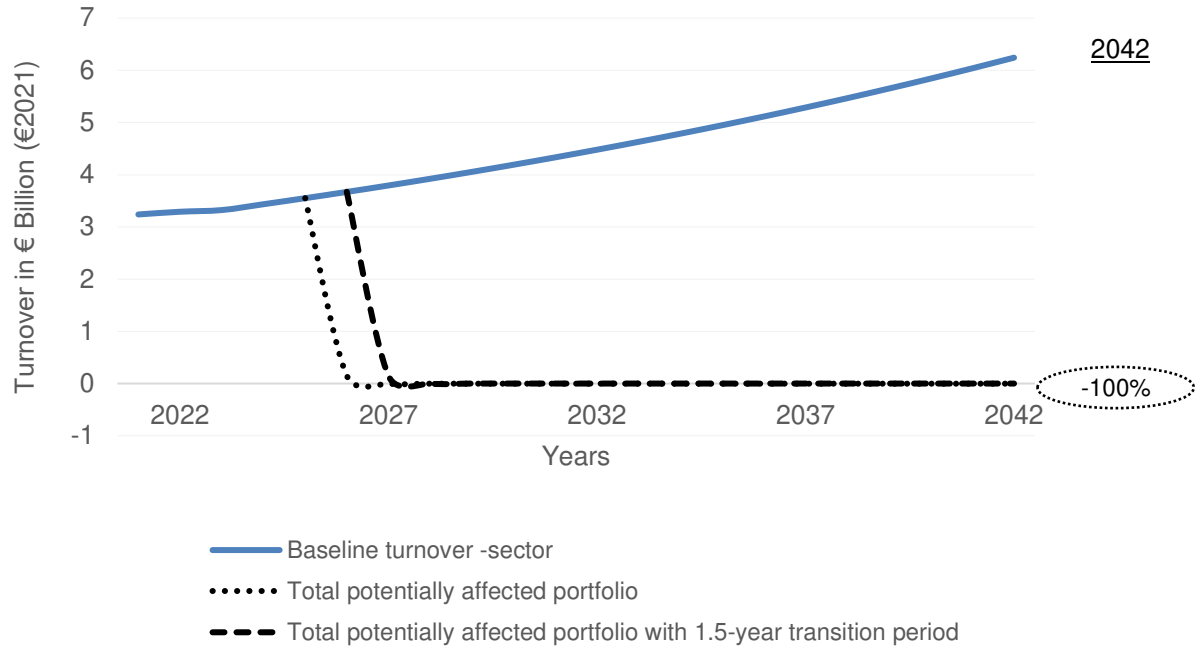
#### *6.2.1.1 The affected portfolio*

Thirteen PFAS manufacturers and importers responded to the survey. These are considered to be broadly representative of the PFAS manufacturing and importing sector; however, it has not been possible to confirm the proportion of the market captured by these respondents.

The survey participants considered the products in their 2021 product portfolio that could be affected if the proposed restriction was fully adopted with immediate effect (i.e., in 2025). **The size of the 'total potentially affected product portfolio' is the total baseline turnover from PFAS.** The 'total potentially affected portfolio' reflects the products that may be in scope of the restriction proposal and provides a maximum scale of impact on the size of the operations of EEA PFAS manufacturers and importers, where no mitigation actions are implemented and no exemptions or derogations are granted.

Figure 6-1 visually illustrates the size of the portfolio of products in scope of being affected by the proposed restriction as the baseline projections of turnover from PFAS as reported by manufacturers and importers of PFAS.

Figure 6-1 Product portfolio (in terms of turnover) that is in scope of potentially being affected by the proposed restriction of PFAS (sample only)




The dotted line represents a situation in which the restriction is made effective upon entry into force of the legislation, which is expected by 2025. The dashed line represents the known timeline of the restriction to take effect, as written in the restriction proposal published 7th February, with a transition period of 1.5 years.

The potentially affected portfolio of products, 100% of the turnover from the sale of PFAS in the EEA, could be considered an unlikely upper bound for the impact on the EEA PFAS manufacturers' sales, if the proposed restriction is adopted in full and the EEA PFAS manufacturers do not adapt, where possible, to mitigate these impacts. However, some potential substitution levels are reported by PFAS manufacturers and importers, albeit low levels. Although uncertainty remains, this representation of the potentially affected portfolio of products with no feasible substitution by manufacturers and/or importers is, based on survey responses, unlikely to represent the final potential impact of the restriction on PFAS manufacturers and importers, as some mitigation strategies remain feasible and both policy scenarios 2 and 3 in this Study allow for derogations.

#### *6.2.1.2 Potential business response*

Substitution may occur at manufacturer or importer level, and reformulation with alternatives to PFAS, likely to happen further down the value chain of the sector, at the level of PFAS downstream users. That is in line with the findings from the survey for downstream users, which is discussed in Section 6.3.

With respect to the scope of potential substitution, reformulation and other alternatives feasible to PFAS manufacturers and importers, and based on survey data, **it is estimated that 9% of the turnover from PFAS can be recovered by some of the following mitigation strategies**: replacement of PFAS with alternatives that are suitable for some of their current uses. This scope of potential substitution is invariant by Scenario 1, 2 or 3, although respondents were given the possibility to provide different levels in each scenario. This suggests that the scope of known alternatives (alternatives that are already on the market or have already been developed and can be brought to the market quickly) for PFAS manufacturers and importers may be equally narrow in any case. The variability among respondents of the potential scope of substitution is low.

Additionally, there are further uncertainties regarding the timeline by which the restriction will take effect for PFAS manufacturers and importers. First, the proposal stipulates that there will be a transition of 1.5 years in all cases from the restriction entering into force to the restriction being fully implemented. Second, in each of the Scenarios 2 and 3, there is a different scope of potential derogations. According to the restriction proposal text published 7th February 2023, most of the potential derogations will be time-limited (see Section 4.1), but the proposal specifies some applications and uses of PFAS that have been selected for a 5-year derogation and other applications and uses of PFAS that have been selected for a 12-year derogation (both additional to the 1.5-year transition period). Impacts of the restriction, that is, including the scope of substitution, reformulation and other alternatives, will therefore be overlayed with this timeline, which will include the scope of potential derogation in each Scenario. This scope of derogation is, as reported by PFAS manufacturers and importers, 62% in Scenario 2 (restriction proposal of 7th February), and 48% in Scenario 3 (full restriction and voluntary applications for derogation).

Therefore, although available evidence shows a very limited expectation of successful substitution and reformulation to mitigate lost portfolio of PFAS by their manufacturers and/or importers, businesses might still initiate some actions to adhere to the restriction and/or mitigate any adverse effects with alternatives or substitutes to the extent possible. This would involve adjusting capital and/or R&D expenditure plans and manufacturing or operating processes more broadly.

However, given the majority of potential derogations are time-limited, the final impact after all derogations have ceased, and all substitution strategies have been implemented will be the difference between the affected portfolio and the scope of substitution (i.e., estimated 9% of the turnover from PFAS, as above). This could change if unforeseen innovation delivered feasible alternatives to PFAS that maintained key properties thereof, but the widespread consensus among industry members is that it is unlikely that suitable alternatives can be found for all applications.

#### *6.2.1.3 Potential market impacts*

In summary, it is estimated that most of the portfolio of products (substances, mixtures) currently manufactured and/or sold in the EEA could no longer be placed on the market, without substitution by PFAS manufacturers/ importers[73], meaning that the economic activity would eventually cease leading to potential significant reductions in market size and knock-on implications further down the value chain. Estimates are presented in

[73] There may be an increase in market share for companies which manufacture alternatives. The manufacturers and importers who responded to this survey noted that they do not have the ability to transform their current manufacturing facilities to be able to manufacture alternatives in the majority of cases and so it is likely that this action would be carried out by other chemicals companies who have the correct manufacturing facilities.

the Table below, by scenario, and based on the manufacturers and importers' current knowledge of availability and R&D plans and not accounting for unknown or unforeseen technical advancements.

Table 6-1 Summary of impacts, scope of substitution strategies and derogation by restriction Scenario. Source: survey to PFAS manufacturers and importers.

| Impacts of the restriction | Scenario 1 | Scenario 2 | Scenario 3 |
|---|---|---|---|
| **Affected portfolio (turnover from PFAS)** | 100% | 100% | 100% |
| **Substitution, reformulation, alternatives (% of affected portfolio)** | 9% | 9% | 9% |
| **Derogation (% of affected portfolio)** | 0% | 62% | 48% |
| **Final impact by 2042** | 91% | 91% | 91% |

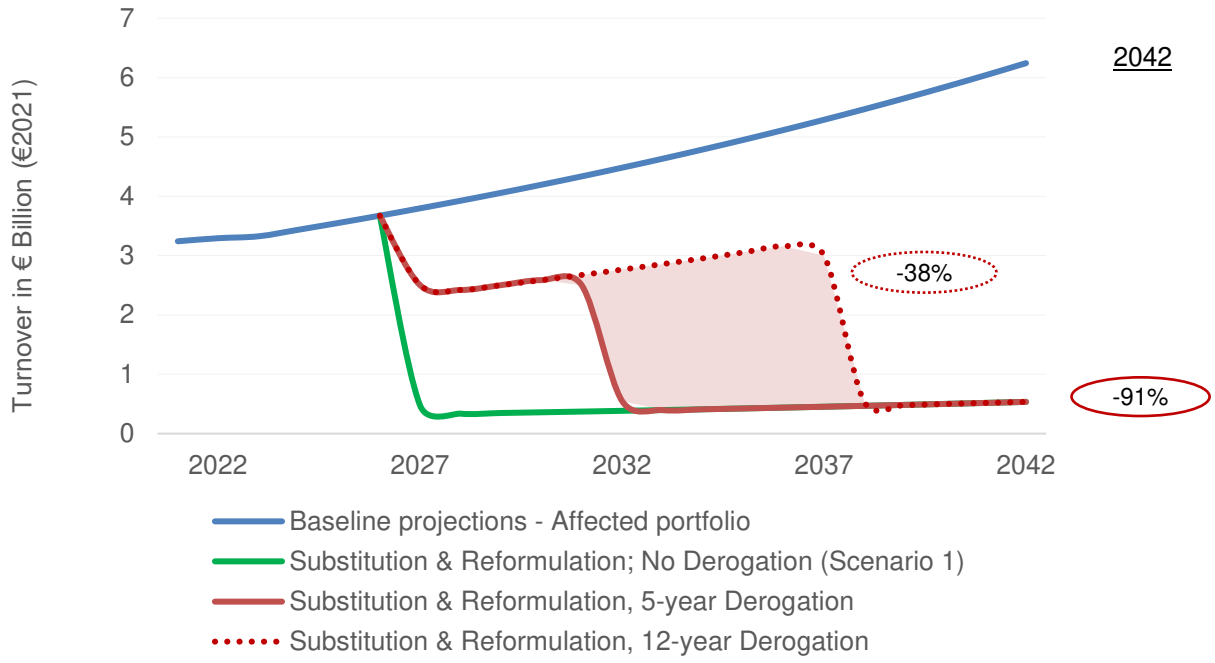
The following sections explore the net impacts of the policy options on EEA PFAS manufacturers and importers across a number of business and economic indicators, overlay the timeline of effects, and explore the sensitivity of some of the key assumptions employed in the analysis, and consider the core limitations.

### 6.2.2 Turnover from PFAS manufacturers and importers

The turnover from PFAS according to the sample of manufacturers and importers that participated in the consultation undertaken for this Study is estimated to be around €3.2 billion in 2021. The implementation of the proposed restriction is estimated to reduce the turnover of PFAS manufacturers and importers. As reported by survey participants, substitution and reformulation strategies amongst PFAS manufacturers and importers is estimated to be limited, and up to 9% of the turnover from PFAS, on average. Therefore, it has been estimated that manufacturers could lose 91% of the PFAS production portfolio, as there is no known or foreseen possibility to further mitigate the impact from the perspective of substitution, reformulation or other productive changes at present. More mitigation strategies are, on the other hand, expected to be developed by downstream users (see Section 6.3).

Further, the implementation of time-limited derogations can delay, to some extent, this impact. According to PFAS manufacturers, in Scenario 2, they might expect a scope for time-limited derogations of around 62% of their PFAS portfolio, in terms of their turnover value, and 48% in Scenario 3. These results are shown over time in Figure 6-2 and Figure 6-3 below, for Scenario 2 and for Scenario 3, respectively, and including Scenario 1 for reference.

Figure 6-2 Estimated impacts of the PFAS restriction on turnover from surveyed PFAS producers and importers against the baseline scenario (€ 2021). Scenario 2 (and Scenario 1 in green).



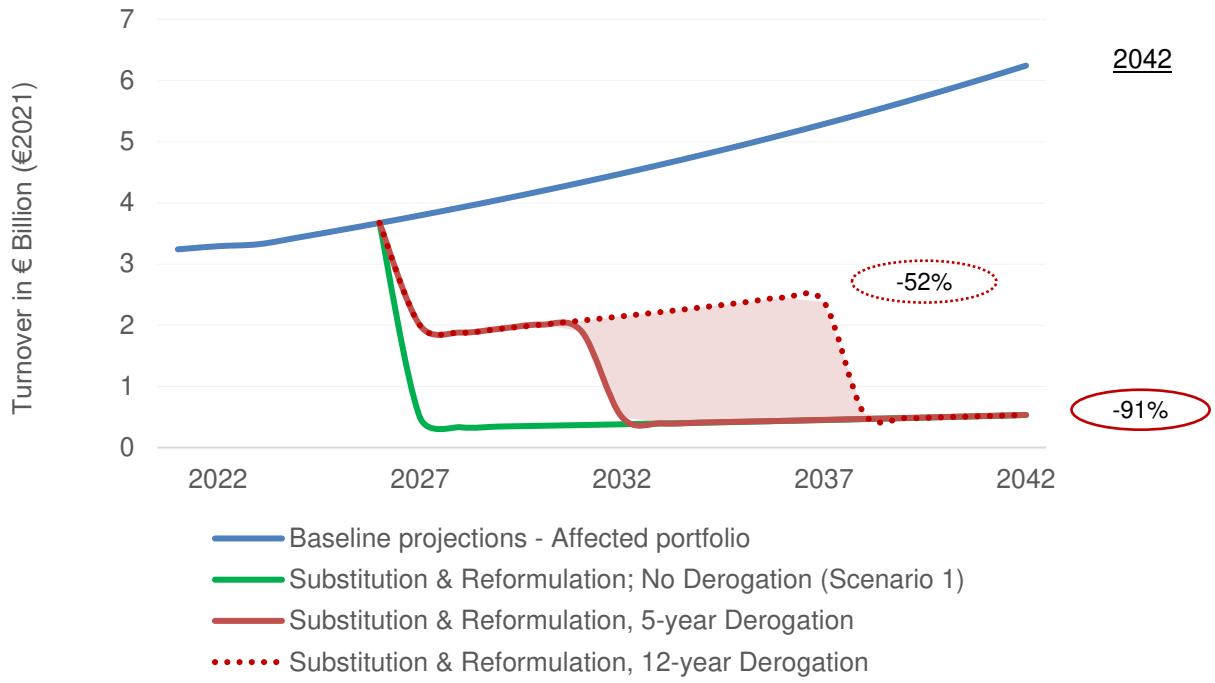

The green solid line shows what the potential turnover losses could be if the restriction took place immediately and in full after the 1.5-year transition period. That is, the share of the PFAS production portfolio that cannot be substituted or replaced with alternatives of any type, 91%.

The red solid line shows the pathway for potential turnover losses if derogations are granted according to the expectation of scope for derogations reported by survey participants, for a period of 5 or 12 years additional to the 1.5-year transition period, in Scenario 2 or Scenario 3. There is an initial drop after the 1.5-year transition period, when the share of PFAs portfolio that is not subject to derogations is lost. There is uncertainty in what share of the portfolio of PFAS manufacturers and importers will obtain a 5-year or a 12-year derogation. That is represented in both Figures by the red-shaded area. By 2039, the 12-year derogations have ceased, and hence, the full extent of losses for PFAS manufacturers is realised, converging to the impact of 91% of the turnover from PFAS shown by the green solid line, 'Substitution & Reformulation, No derogation'.

The share of turnover from PFAS that is subject to each timed derogation will determine the extent of annualised losses in euros. A range is provided with a lower bound (all derogations are for 12 years) and an upper bound (all derogations are for 5 years) for turnover losses in each Scenario.

Turnover losses at the end of the period, in the impact variant with no derogations, are the same in both Scenarios 2 and 3, resulting from the fact that the scope for substitution is considered the same in both of them.

Figure 6-3 Estimated impacts of the PFAS restriction on turnover from surveyed PFAS producers and importers against the baseline scenario (€ 2021). Scenario 3 (and Scenario 1 in green).




These first-order effects (as shown in Figure 6-2 and Figure 6-3) reflect the direct business responses to the proposed restriction up until 2042. Most of the EEA PFAS market could be lost by the end of the period, representing 91% on average of the turnover from PFAS manufacture and import, and equating to a turnover that is €5.7 billion less than the projected baseline in that year. The first-order effects do not include the potential impacts of companies passing on the additional regulatory burden to their customers, which would be termed 'second-order effects'.

In annualised terms, PFAS manufacturers and importers are estimated **to lose €3.5 billion (€ 2021) of turnover each year on average over the period 2024-2042, when compared to the baseline scenario if there were no derogations (Scenario 1)**, and **between €2.1 and €2.9 billion per year on average in Scenario 2**, and **between €2.5 and €3.0 billion per year on average in Scenario 3**.

The low scope for substitution and reformulation reported by PFAS manufacturers and importers does not mean that there will be no alternatives; rather, it is expected that alternative products and technologies without PFAS that provide similar properties to products may be developed by other actors in the chemicals sector and also in other sectors, directly as alternatives to the current applications. This has been indeed clarified by some respondents, as this development might not be in the scope of activities of PFAS manufacturers and/or importers at present due to their current manufacturing facilities requiring decommissioning and new facilities needing to be built. See Section 6.3 for more insight about how substitution could happen further down the value chain.

### 6.2.3 Gross Value Added (GVA)

A REACH restriction of PFAS is also estimated to impact PFAS manufacturers and importers' Gross Value Added. GVA is affected by changes in turnover and intermediate consumption. The proposed restriction is estimated to result in reductions in turnover as well as in intermediate consumption, reducing overall GVA. This impact on GVA would be considered as a first-order effect, without considering indirect price effects.

When compared to the baseline scenario, the analysis results in estimates that **the EEA PFAS manufacturers and importers' GVA could fall by €1.5 billion per year on average between 2024 and 2042 in Scenario 1 with no derogations, and by €0.9-1.2 billion in Scenario 2, and by €1.0-1.3 billion in Scenario 3**. These impacts are considered direct because they exclusively affect the EEA PFAS manufacturing/ importing companies. Such impacts could have knock-on repercussions on the international supply chain (indirect

effects) and the wider EEA economy (induced effects), reducing the sector's contribution to GDP even further. Although more insights can be collected from the analysis of the impacts of the PFAS restriction on participating PFAS downstream users (see Section 6.3), Box 6-1 below shows the knock-on implications resulting from an input-output analysis of the GVA impacts to PFAS manufacturers and importers.

Box 6-1 Knock-on effects of the PFAS restriction from manufacturers and importers to the EU-27 economy[74].

**Total impacts on the economy: The direct, indirect and induced effects**

The decrease in the GVA of the EU PFAS manufacturers and importers is likely to have knock-on effects on the sector's international supply chain (indirect or Type I effects). The direct and indirect effects are also estimated to translate into a fall in employment and thus overall compensation, which would in turn further reduce consumption and have broader implications across the economy (induced or Type II effects).

The indirect and induced effects, and thus, the total impacts on the economy driven by the effects of the proposed restriction have been estimated using an Input-Output methodology. The cumulative Type I and Type II multipliers have been assumed to be around 2.8 and 3.4 respectively, based on evidence from Eurostat, national statistical databases from across Europe and expert judgment.

Based on this, **total decreases in GVA driven by the effects of the proposed restriction on the EEA PFAS manufacturers and importers are estimated to be €4.9 billion every year on average between 2024 and 2042 in Scenario 1, €3.0-4.1 billion every year on average between 2024 and 2042 in Scenario 2, and in Scenario 3, total GVA decreases could range from €3.5-4.3 billion every year on average, which would be equivalent to a decrease of 0.02-0.04% in the EU-27 GDP (2021).**

Source: Ricardo analysis based on Eurostat data and a bespoke survey of Cefic and partner associations members.

### 6.2.4 Intermediate consumption and operating costs

The PFAS manufacturers and importers surveyed confirmed that they would need to implement negative changes in their production, ranging from just reducing capacity to dropping more than 2 production lines and/or sites in the next 10 years as a result of the proposed restriction; none of them indicated an expectation of any positive change in their manufacturing activity.

Chemical companies are assumed to reduce their operating activities as a result of the withdrawal of PFAS products from the market. This could in turn lead to a reduced operating expenditure proportional to turnover losses against the baseline. Operating costs are estimated to decrease by an annualised amount of €1.9 billion per year between 2024 and 2042 in Scenario 1, €1.1 to 1.6 billion per year between 2024 and 2042 in Scenario 2, and €1.3 to 1.7 billion per year between 2024 and 2042 in Scenario 3. These impacts represent from 62% to 90% of their operating expenditure attributed to PFAS in 2021.

The investments expected by PFAS manufacturers and importers to find alternatives and/or substitutes to alleviate the estimated reduction in their business would not reportedly increase operating expenditure or intermediate consumption in comparison to PFAS manufacture. Derogations would, however, involve an operating expenditure to develop the necessary alternatives in some applications, and this cost was estimated to be €14 million annually during the first 10 years after the restriction is enforced.

### 6.2.5 Capital R&D expenditure

Similarly, the proposed restriction could have an impact on chemical businesses' capital and R&D expenditure. If their company size shrinks, it is assumed that their overall spending will shrink as well. As an example, a 10% drop in the size of chemical companies' turnover in the EEA might result in a corresponding reduction in overall investment, equating to €130 million.

Due to the lack of opportunities for substitution and reformulation, overall **capital expenditure related to PFAS manufacture and import is estimated to fall by around €900 million per year in Scenario 1, between €600 and €800 million per year between 2023 and 2042 in Scenario 2, between €700 and €800 million per year between 2023 and 2042 in Scenario 3, in annualised terms against the baseline**. This fall represents between 40% and 70% of the total Capex from the surveyed manufacturers and importers in 2021, and is assumed to account roughly for the lost production lines and sites. Capex or R&D expenditure

[74] Input-output tables are limited to the EU-27, and therefore knock-on effects refer only to the EU.

associated with products that would be discontinued as a consequence of the regulatory changes is unlikely to be retained in the EEA; it might be developed elsewhere, although no strong evidence on this could be collected.

### 6.2.6 Employment

The analysis estimates that restricting the manufacture, placing on the market and use of PFAS could result in a direct net decline in jobs related to PFAS manufacture and import. This decrease is mostly due to the estimated drop in the size of the PFAS manufacturers' sector as a result of the proposed restriction.

The impact of the proposed restriction on employment is estimated to be lower than the impact on turnover. This was supported both by looking at past trends and the responses to the stakeholder consultation. According to the latter, the number of employees in PFAS-related production lines represented 30% of the total employment of the surveyed companies. Each of these jobs could be lost under the proposed restriction.

However, evidence on the impacts of REACH, e.g., CSES *et al*[75], suggests that additional compliance costs led to increased labour requirements in the chemicals sector, not only due to needing additional staff but also due to additional remuneration, skills, training and/or retraining costs. Although the additional compliance costs are estimated to be minimal for manufacturers as their adaptation needs to the proposed restriction are very limited, there could still be some instances of retraining of workers to adapt them to other manufacturing lines.

**In this context, based on the sample of respondents it is estimated that, by the end of 2042, around 14,300 jobs directly employed in PFAS manufacture and import could be impacted against the baseline scenario in any Scenario, which is equivalent to 30% of the surveyed PFAS manufacturers' workforce in that year[76].** This high number of job impacts is attributed to the fact that PFAS manufacturers do not expect to be able to retain business by reformulating and substituting PFAS products, although the possibility that job impacts are mitigated by relocation of workers to other business areas is considered and included in this result.

The above impacts only consider the direct impacts as a result of legislative changes to the sector. However, it is assumed that a second-order impact will follow, as impacts on the supply chain (indirect effects) and the wider EU economy (induced effects), leading to even larger reductions in the sector's contribution to employment.

Box 6-2 Knock-on effects of the PFAS restriction from manufacturers and importers to EU employment[77]

**Total impacts on employment: The direct, indirect and induced effects**

The impact on jobs in the EU PFAS manufacturing sector is likely to have second-order impacts throughout the supply chain upstream (indirect or Type I effects). These direct and indirect impacts are projected to result in changes in overall compensation and, as a result, disposable income, further reducing consumption and having broader economic implications (induced or Type II effects).

Using an Input-Output technique, the indirect and induced effects, as well as the total economic consequences of the policy alternatives on the EU chemicals sector, have been calculated. The cumulative Type I and Type II multipliers have been assumed at around 2.1 and 3.1 respectively, based on evidence from Eurostat, national statistical databases from across Europe and expert judgment.

Based on this, **the adoption of the proposed restriction could lead to a reduction of 44,000 jobs by 2042 when compared against the baseline, which would be equivalent to a reduction of 0.02 percentage points off total employment in the EU-27 in that year.**

Source: Ricardo analysis based on Eurostat data and a bespoke survey of PFAS manufacturers and importers

## 6.3 COSTS AND BENEFITS TO DOWNSTREAM USERS OF PFAS

**173 downstream users of PFAS in 30 different downstream user application sectors[78]** considered the products in their 2021 product portfolio that could be affected, if the restriction proposal was fully adopted with immediate effect (i.e., in 2025). As shown in Figure 6-4 below, PFAS play different roles in the operations of

[75] CSES et al (2015). *Monitoring the Impacts of REACH on Innovation, Competitiveness and SMEs*. Available from: monitoring-the-impacts-of-reach.pdf

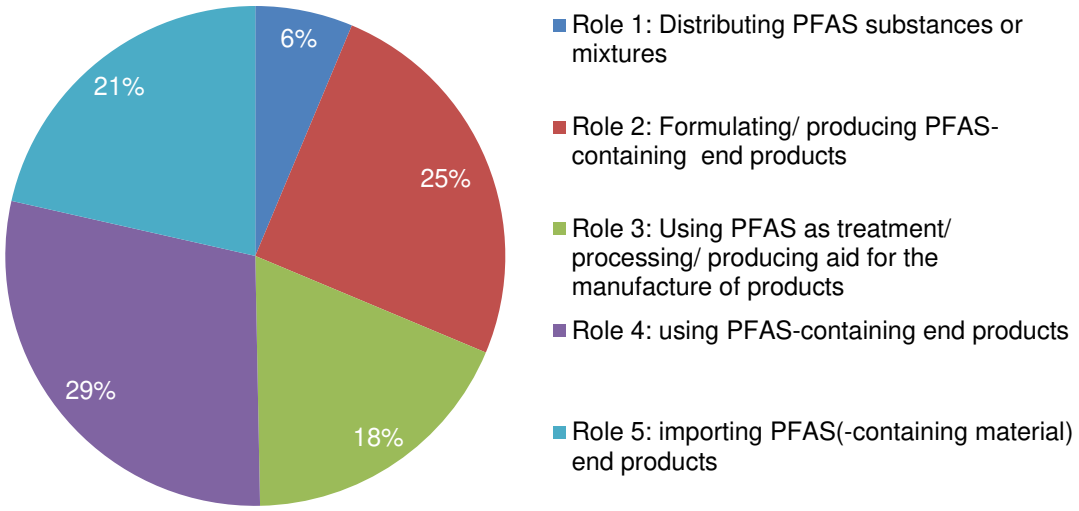
[76] Most PFAS manufacturers and importers also develop other economic activities, and therefore, they will maintain employees dedicated to them; in the case of our survey participants, this was estimated to be 70%.

[77] Input-output tables are limited to the EU-27, and therefore knock-on effects refer only to the EU.

[78] 30 different sector divisions participated in the survey, although some of them are subsectors within larger categories. Taking this into account, the number of sectors consulted is 22.

the participating PFAS downstream users. The two largest roles are: 31% of the respondents reported to *use* products containing PFAS in their operations, and 24% of the sample *produce* products containing PFAS. More importantly, 18% of the sample use PFAS as a treatment aid for their operations. A similar picture is depicted at the sectoral level as shown in Figure 7-1 in Appendix 4.

Figure 6-4 Roles of operations related to PFAS: all participants.




Therefore, the analysis presented in the sections below for downstream users include supply chain impacts, meaning that potential losses go beyond just products containing PFAS, and include products that use PFAS in any way in their production process as well. The size of the **'total potentially affected product portfolio'** was estimated to be around 63% of the total turnover from participating downstream users in our consultation, which would be equivalent to €159.2 billion in 2021. That means that 63% of participating PFAS downstream users' income (€254.1 billion as shown in Section 5.2.2) comes from products that contain PFAS or use PFAS in their production, in any of the 5 roles presented above today.

The simple average percentage of the product portfolio (in terms of turnover) that may be affected by the adoption of the proposed restriction is very polarised among survey respondents. In 2021, the turnover-weighted average affected portfolio is 63%. However, estimates of the potentially affected portfolio differ notably by company participating in the survey. Turnover from the *Manufacture of bulk, large scale chemicals* and the *Agriculture, forestry and fishery* sectors, for instance, highly depend on the sales of products reliant on PFAS, whereas in other sectors such as *Organic chemicals*, only around 5% of their sales rely on PFAS. This is further explored in Table 6-2 below.

Table 6-2 Affected portfolio and total turnover for each type of PFAS downstream user application (€ 2021).

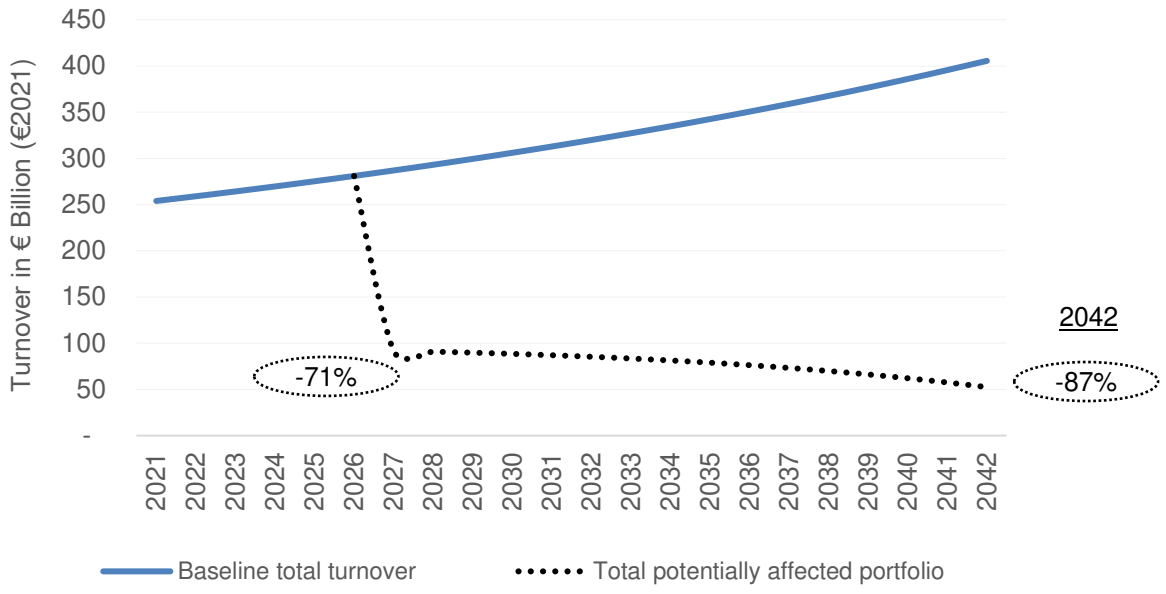
| Application | Total turnover from application (€ 2021) | Potentially Affected Portfolio (% of turnover from each type of application) |
|---|---|---|
| Agriculture, forestry, fishery | €0.2 billion | 95% |
| Manufacture of textiles, leather, fur | €0.4 billion | 31% |
| Manufacture of Personal Protective Equipment | €4.0 billion | 72% |
| Manufacture of plastics products, including | €47.5 billion | 31% |

| Application | Total turnover from application (€ 2021) | Potentially Affected Portfolio (% of turnover from each type of application) |
|---|---|---|
| compounding and conversion | | |
| Paints and coatings | €1.3 billion | 9% |
| Lubricants | €1.2 billion | 33% |
| Manufacture of bulk, large scale chemicals (including petroleum products) | €3.0 billion | 94% |
| Organic chemicals | €9.6 billion | 5% |
| Inorganic chemicals | €10.5 billion | 32% |
| Manufacture of fine chemicals | €0.5 billion | 86% |
| Pharmaceutical | €22.0 billion | 81% |
| Medical devices | €4.5 billion | 88% |
| Manufacture of electrical and electronic equipment (including components and semiconductors), except large machinery and equipment | €19.5 billion | 76% |
| Electronic components | €12.3 billion | 84% |
| Computers, small and large printers, electronic and optical products | €27.4 billion | 82% |
| Medical equipment | €3.0 billion | 85% |
| Energy-related (including electrical) equipment | €2.2 billion | 44% |
| Other small-scale equipment | €4.0 billion | 92% |
| General manufacturing, e.g. machinery, equipment, vehicles, other transport equipment (excluding electrical equipment) | €26.8 billion | 77% |
| Transport (automotive, aviation, rail, aerospace) | €12.0 billion | 76% |
| Technical equipment for industrial use (e.g. for chemical industry) | €24.0 billion | 91% |
| Building and construction work | €0.6 billion | 33 % |

| Application | Total turnover from application (€ 2021) | Potentially Affected Portfolio (% of turnover from each type of application) |
|---|---|---|
| Electricity, steam, hydrogen, gas, batteries and fuel cells | €0.6 billion | 64% |
| Water supply, water treatment and sewage treatment | €2.1 billion | 79% |
| Research and development | €0.1 billion | 80% |
| Scientific R&D | €0.1 billion | 93% |
| Life Sciences | €0.5 billion | 25% |
| **Total** | **€254.1 billion** | **63%** |

This estimate of the 'total potentially affected product portfolio' captures all products that contain or rely on PFAS for their manufacture. This may be final products that contain PFAS, such as impregnated PPE, or non-PFAS products that require PFAS processing aids/ intermediates or are made by machinery that require PFAS to operate (e.g. sealing devices) (see Figure 6-5) and are thus expected to be affected in some way by the restriction proposal. Therefore, Figure 6-5 presents estimates of the size of the portfolio of products that could be affected by the proposed restriction, against the baseline turnover from PFAS downstream users in the sample of survey participants. It should be stressed that the affected portfolio could be larger where there are supply chain disruptions caused by the need for PFAS in the manufacture of key raw materials, such as the use of membranes.

Figure 6-5 Product portfolio (in terms of turnover) that is in scope of being affected by the policy changes against PFAS downstream using companies' market baseline projections (sample only).




Source: Ricardo analysis based on Eurostat data and a bespoke survey to PFAS downstream users.

These estimates could be considered unlikely upper bounds for the potential reduction of the participating EEA PFAS downstream users' market in the event that the proposed restriction is adopted in full, and the participating EEA PFAS downstream users do not adapt, where possible, to mitigate these impacts. Although

uncertainty remains, this projection of the potentially affected portfolio of products is taken forward as the basis for quantifying the potential impacts on the EEA PFAS downstream users and knock-on effects on the broader economy.

According to the expected regulatory timeline, the restriction would not be likely to enter into force before 2025, with a transition period of 1.5 additional years. That is, the restriction would start to be effective around 2027. Evidence collated from the survey was thus overlayed with this potential implementation schedule to produce an estimate of sales turnover that would exclude the potentially affected portfolio of PFAS from 2021-2040, showing an estimate of the maximum potential losses within the sector in a scenario where no alternatives are found for PFAS. By 2042, it is estimated that 87% of the total portfolio of products manufactured or formulated by PFAS downstream users could face use restrictions. The remaining 13% of the PFAS downstream users' portfolio is estimated to be substances, mixtures and/or articles that do not contain PFAS, or rely on PFAS for their manufacture, and hence will continue production following a business-as-usual scenario.

The size of the affected portfolio also evolves over time. Considering the current sample of downstream user sectors and their market sizes, in 2021 around 63% of participating PFAS downstream users' turnover came from the sale of products that use or contain PFAS. However, the different growth rates of the affected sectors may increase the size of the affected portfolio over the period (71% in 2027 and 84% in 2040). In other words, those sectors that are estimated to grow at higher rates also estimated to have a larger affected portfolio (i.e., reliant on PFAS). The evidence collected for this study suggests that, in response to the affected portfolio that may face direct restrictions on the use of PFAS (estimated 63% of the total participating PFAS downstream users' portfolio in 2021), downstream users could substitute and/or reformulate between 0% and 95% of these potentially affected products to mitigate what would otherwise be market losses. This will depend on a positive market uptake and on whether the alternative products maintain the same function and effectiveness[79]. The **central estimates, averaged and weighted across sectors, for substitution and reformulation are 37% of the affected portfolio under Scenario 1, 66% of the affected portfolio under Scenario 2, and 50% under Scenario 3**. Box 6-3 outlines the evidence collected related to the participating EEA PFAS downstream user companies' capacity to substitute and/or reformulate that has been considered in this analysis.

Box 6-3 Substitution and/or reformulation of products that may be affected by the policy options.

173 businesses were surveyed to gather evidence as to the extent to which they may implement specific actions resulting from the adoption of policy changes and their likely scale, especially including substitution and/or reformulation.

Businesses surveyed suggest that they **could be able to substitute and/or reformulate around 37% of the products (in terms of turnover) that may be affected under Scenario 1, 66% under Scenario 2, and 50% under Scenario 3**, although there is some uncertainty and dispersion. These central estimates are averages weighted by each respondent's turnover, but responses widely vary.

Business expectations are affected not only by what might be technically and economically feasible but also how their customers may react to the substitutes and/or reformulated products, and more importantly, the availability of time and resource to innovate and bring alternative products to the market.

The survey suggests that the ability of businesses to substitute the affected products could range between 5% and 95% of their affected portfolio in Scenario 2 and between 0% and 95% in Scenarios 1 and 3 (in turnover terms) depending on the downstream user application, on average, although this is uncertain. It is assumed that given time in the form of a derogation, while losses are delayed, the market could attain a larger level of substitution, as the necessary investments can be made without the financial restraint of the full restriction early on. If the restriction is enforced with no derogations in 2027, substitution could be assumed to happen more slowly and losses in market value could be reflected from the beginning of the period. Early losses might preclude some of the potential substitution and innovation as companies could be more

[79] This estimate for substitution and reformulation is larger than the one found in Phase 1 of this study for the overall chemicals sector's response to changes to the CLP and extension of the GRA, where 33% of the portfolio in scope of bans was reportedly expected to be substituted and/or reformulated. However, it is in line with other studies for downstream users within the chemicals sector, that show that they may be able to substitute more of the ingredients of their formulas than pure substance manufacturers.

financially restrained. This is reflected in the corresponding final turnover impacts shown in the next subsection.

Further, around 10% of respondents suggest that substitution and/or reformulation would not surpass 20% of the products in their affected portfolio, while 5% of the respondents think it will be above 90% of their affected product portfolio. **The ability of businesses to substitute and/or reformulate will be very different across business type, size and sub-sector.**

Businesses may also **need time to adjust their operations and establish a final substitute and/or reformulated product that can be placed on the market**. In some cases, businesses may already have a readily marketable alternative to place on the market upon adoption of policy changes. In others, businesses may require years of research and development and product approval before an alternative can be brought to the market. Based on survey responses, participating PFAS downstream users, on average, suggest a lead time of 5.8 years to bring a substitute and/or reformulated product to the market. However, the lead time varies considerably by type of application, between an estimate of 4.1 years in *Life* sciences and 17.8 years for *Manufacture of bulk, large scale chemicals (including petroleum products).* A summary of the lead time to bring a substitute and/or reformulated product to market is presented in Table 6-3 below. The lead times presented below are estimates based on current understanding of R&D efforts. Where supply chain disruption is caused by the proposed restriction, such as access to raw materials, these lead times may increase significantly.

Table 6-3 Potential lead time to bring a substitute to market for each type of application in number of years.

| Type of application | Lead time to bring a substitute to market (number of years) |
|---|---|
| Agriculture, forestry, fishery | 8.6 |
| Manufacture of textiles, leather, fur | 4.3 |
| Manufacture of Personal Protective Equipment | 6.4 |
| Manufacture of plastics products, including compounding and conversion | 7.0 |
| Paints and coatings | 4.9 |
| Lubricants | 7.0 |
| Manufacture of bulk, large scale chemicals (including petroleum products) | 17.8 |
| Organic chemicals | 7.9 |
| Inorganic chemicals | 9.7 |
| Manufacture of fine chemicals | 7.8 |
| Pharmaceutical | 9.4 |
| Medical devices | 10.9 |
| Manufacture of electrical and electronic equipment | 6.5 |
| Electronic components | 5.6 |
| Computers, small and large printers, electronic and optical products | 6.3 |
| Medical equipment | 7.9 |
| Energy-related (including electrical) equipment | 8.0 |
| Other small-scale equipment | 5.0 |
| General manufacturing, e.g. machinery, equipment, vehicles, other transport equipment | 6.4 |
| Transport (automotive, aviation, rail, aerospace) | 11.1 |

| | |
|---|---|
| Technical equipment for industrial use (e.g. for chemical industry) | 6.7 |
| Building and construction work | 4.7 |
| Electricity, steam, hydrogen, gas, batteries and fuel cells | 8.6 |
| Water supply, water treatment and sewage treatment | 4.9 |
| Research and development | 3.4 |
| Scientific R&D | 7.7 |
| Life Sciences | 4.1 |

In conclusion, some substitution and/or reformulation is likely, and businesses will attempt to maximise this where economically viable; this is estimated to mitigate 37%-66% of total potential market withdrawals resulting from regulatory changes but it would take time to implement.

Source: Ricardo analysis based on a bespoke survey of PFAS downstream users.

Businesses are assumed to adjust capital and/or R&D expenditure plans and manufacturing or operating processes more broadly to adhere to new legislative requirements or mitigate any adverse effects. In this case, the evidence collected suggests that businesses have some ability to pass this regulatory burden through to their clients. Additionally, the survey responses suggest that overall export sales of the EEA PFAS downstream users surveyed are limitedly responsive to price changes. As a result, the increase in regulatory burden on products containing PFAS is likely to somewhat affect the market. Box 6-4 outlines the evidence collected of the participating EEA PFAS downstream users' capacity to pass through the increased regulatory burden to their customers, as well as the potential market responsiveness to potential product price changes.

Box 6-4 The EEA PFAS downstream users' response to increased regulatory burden.

**The pass through of regulatory burden for products that may be affected by the proposed restriction**

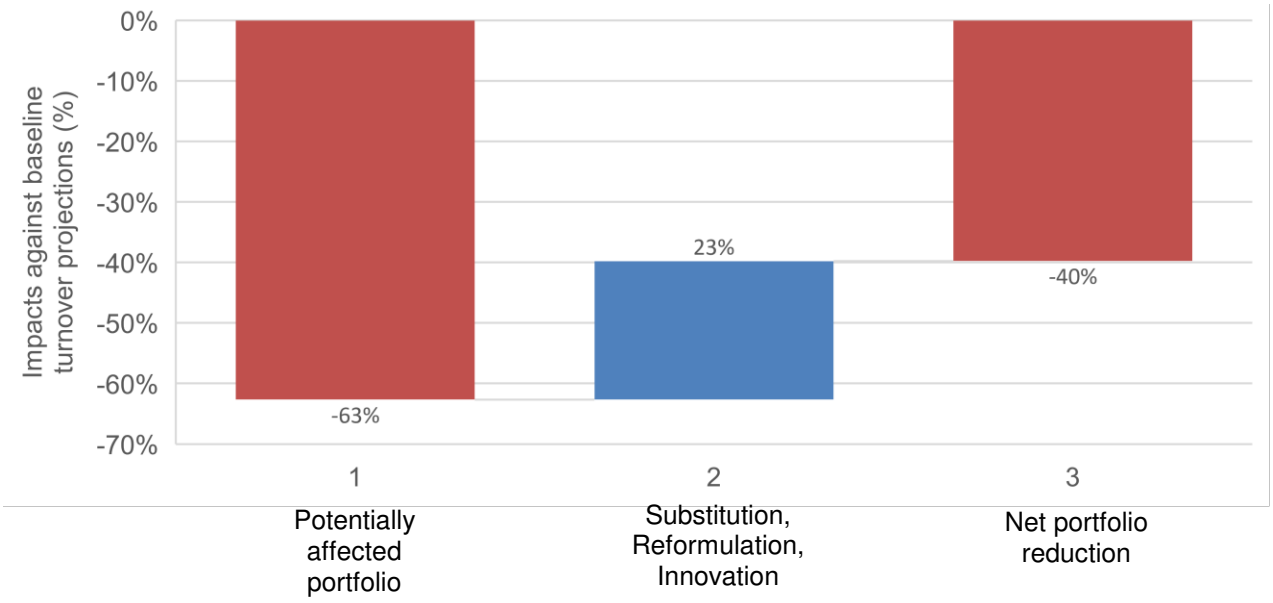
Businesses participating in this consultation also considered the extent to which they would be able to pass through any additional regulatory burden down their supply chain.

However, the ability for a price increase to mitigate impacts or to lead to further turnover losses will ultimately depend on demand elasticity. Only if demand elasticity is larger than -1 will this be a viable strategy, and this might be very different for different sectors. If demand elasticity was lower than -1, this would mean that for any price increase, demand reductions would be larger than the turnover that can be obtained with this higher price, and therefore, increasing prices would not be a feasible option. It was not possible to explore demand elasticity in this study, and therefore, impacts shown here will abstract from second-order effects via prices.

Source: Ricardo analysis based on a bespoke survey of PFAS downstream users.

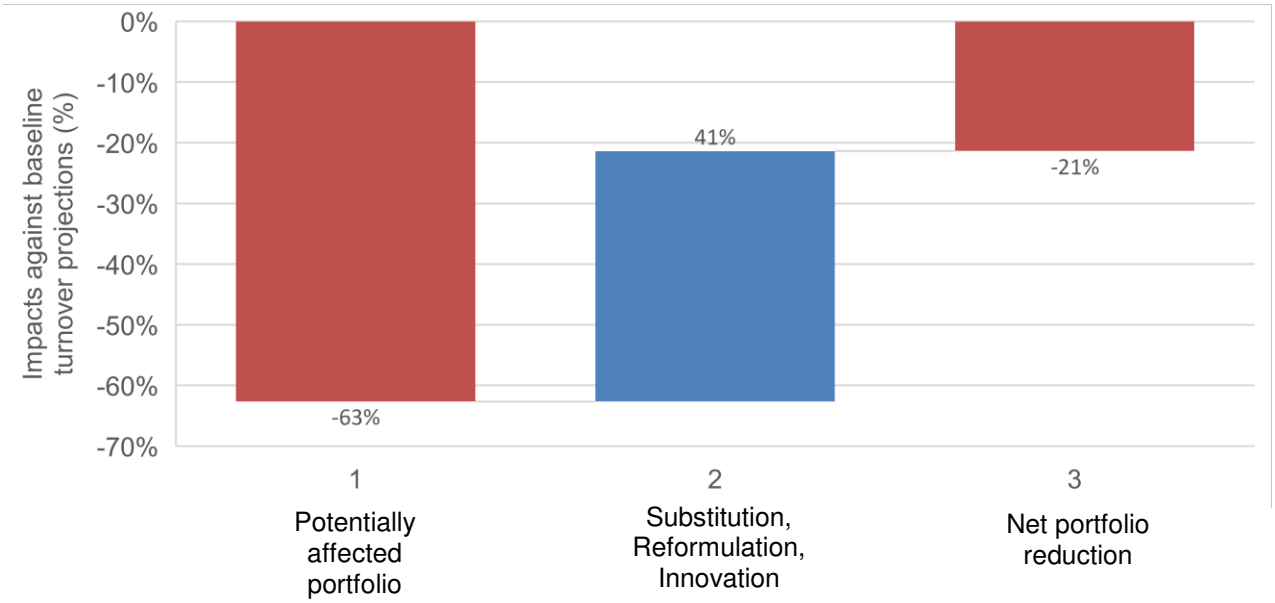
Figure 6-6, Figure 6-7 and Figure 6-8 below illustrate for each of the three Scenarios the different steps of the impact pathway statically, from the estimation of the total potentially affected portfolio, as a percentage of the baseline turnover of surveyed PFAS downstream users, to the potential turnover losses that are estimated to result from the introduction of the proposed restriction considered in this Study (central estimates) after substitution, reformulation and other forms of innovation. In this case, e.g., substitution of 37% of the affected portfolio translates into substitution of 23% of the whole baseline turnover in Scenario 1, and similarly for Scenarios 2 and 3.

Figure 6-6 Static stepwise representation of the portfolio in scope of being affected by the policy changes and assumed responses from businesses in Scenario 1 (as a weighted average of the percentage of baseline turnover of surveyed PFAS downstream users in 2021).



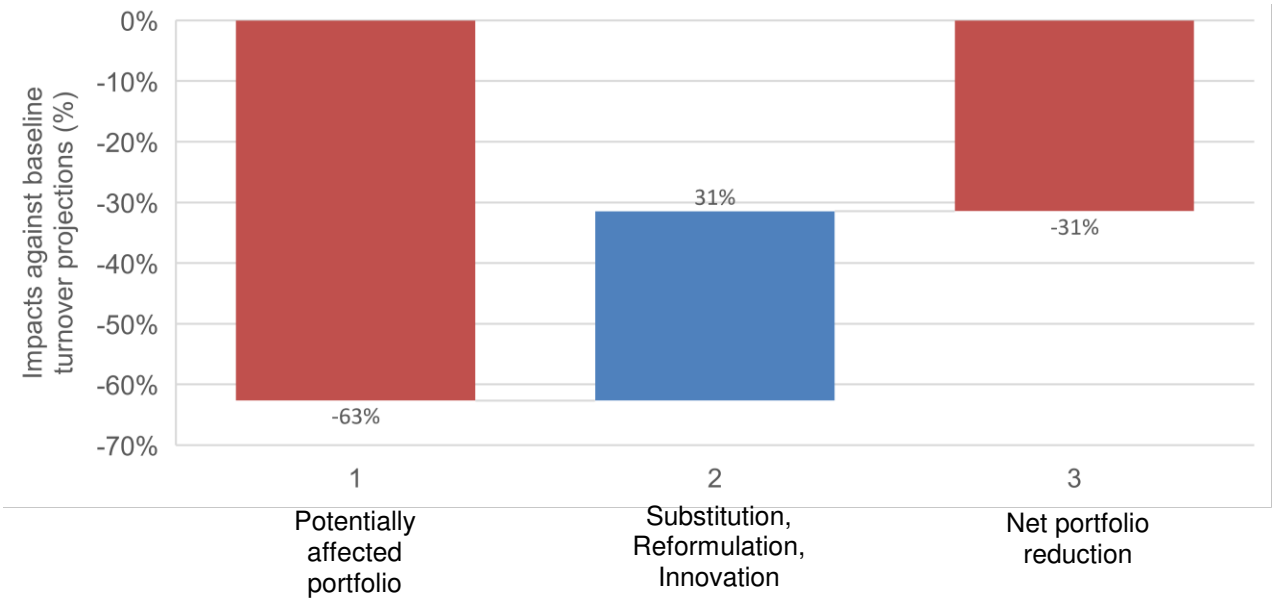

Source: Ricardo analysis based on Eurostat data and a bespoke survey to PFAS downstream users.

Figure 6-7 Static stepwise representation of the portfolio in scope of being affected by the policy changes and assumed responses from businesses in Scenario 2 (as a weighted average of the percentage of baseline turnover of surveyed PFAS downstream users in 2021)




Source: Ricardo analysis based on Eurostat data and a bespoke survey to PFAS downstream users.

Figure 6-8 Static stepwise representation of the portfolio in scope of being affected by the policy changes and assumed responses from businesses in Scenario 3 (as a weighted average of the percentage of baseline turnover of surveyed PFAS downstream users in 2021)




Source: Ricardo analysis based on Eurostat data and a bespoke survey to PFAS downstream users.

In brief, the total potentially affected product portfolio from the proposed restriction (**Step 1**) is equivalent to 63% of the baseline turnover that our sample of PFAS downstream users accrue each year. 37% (Scenario 1), 66% (Scenario 2) and 50% (Scenario 3) of this market (i.e., 23, 41 and 31 percentage points out of 63) may be substituted and/or reformulated (**Step 2**), depending on the Scenario (central estimates weighted by turnover across all respondents).

The feasibility of these levels of substitution, reformulation and innovation will critically depend on time for downstream users to bring these alternatives to the market. If the restriction was to be enforced in 2027 with no further derogations (Scenario 1), it would be expected that feasible substitution at that time would be lowest.

Therefore, this means that the proposed restriction, when accounting for potential business responses, could lead to a reduction in product portfolio and business (in turnover terms) of 40% in Scenario 1, 21% in Scenario 2, and 31% in Scenario 3, out of a total turnover of €254 billion from these companies in 2021, therefore **equivalent to losing €101.0 billion in Scenario 1, and €54.4 billion in Scenario 2, and €79.9 billion in Scenario 3, of the 2021 participating PFAS downstream users' market** (**Step 3**).

As mentioned above, impacts over time will depend on the varying growth trends of each of the sectors, which will determine the weight of each sector at each moment in time, and the overall sum of affected portfolios, scope for substitution and impacts.The following sections describe the net impacts of the policy options on the participating EEA PFAS downstream users across a number of business and economic indicators over time, explore the sensitivity of some of the key assumptions employed in the analysis, and consider the core limitations.

### 6.3.1 Turnover from PFAS downstream users

The adoption of the proposed restriction is estimated to lead to a reduction in the sales of the participating downstream users of PFAS in the surveyed sample in terms of turnover and number of products sold. The extent of this reduction will depend upon the scope and timetable of the legislative changes as well as the type of business responses expected. On average, it has been assumed that companies may need around 5.8 years to adjust their operations and place their substitutes and/or reformulated products on the market. Therefore, Scenario 3, with limited derogations, could negatively affect the potential for substitution of affected companies. In such a Scenario, many companies could experience the portfolio loss first in 2027. The level of substitution and innovation in the market in this situation could be lower than in Scenario 2 (time-limited derogations), where derogations are defined and foreseen for a larger set of applications.

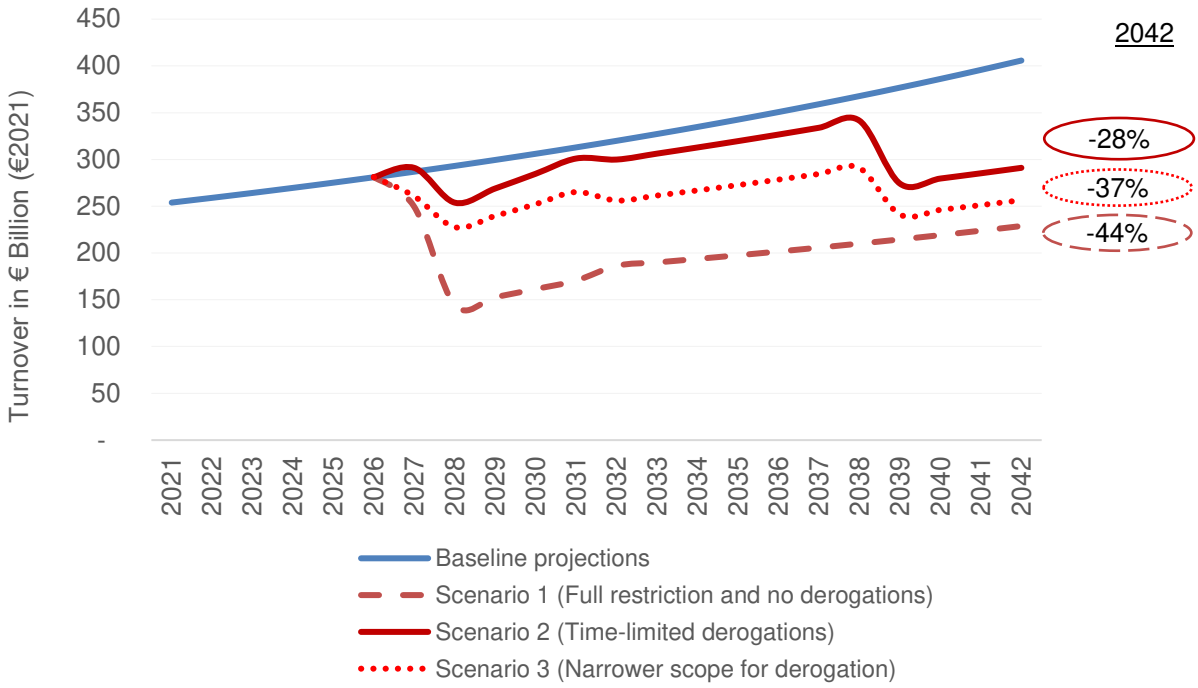
First-order effects, i.e. the impacts on business operations excluding any pass through of additional regulatory costs to customers through price adjustments, are considered in Table 6-4.

Table 6-4 Annualised change in the sample of EEA PFAS downstream users from the baseline scenario in terms of turnover (€ 2021)

| Scenario | First order effects or impacts on businesses overall |
|---|---|
| **Scenario 1** (No derogations) | PFAS downstream users are estimated to **lose €112.7 billion (€ 2021) of turnover each year on average** over the period 2024-2042, when compared to the baseline scenario. |
| **Scenario 2** (Time-limited derogations) | PFAS downstream users are estimated to **lose €30.9 billion (€ 2021) of turnover each year on average** over the period 2024-2042, when compared to the baseline scenario. |
| **Scenario 3** (Narrower scope for derogation) | PFAS downstream users are estimated to **lose €61.4 billion (€ 2021) of turnover each year on average** over the period 2024-2042, when compared to the baseline scenario. |

These impacts are also presented over time in Figure 6-9 below.

Figure 6-9 Estimated impacts of the PFAS restriction on turnover from surveyed PFAS downstream users against the baseline scenario (€ 2021).




Source: Ricardo analysis based on Eurostat data and a bespoke survey to chemical companies.

These first-order effects (as shown in Figure 6-9) reflect the direct business response to the proposed legislative changes: in a scenario with no derogation whatsoever (Scenario 1), companies would experience an immediate loss of product portfolio of anything that involves PFAS that cannot be readily substituted. Over time, some degree of investment to develop alternatives would bring new products to the market, but this would allow a lower level of substitution than a situation in which the enforcement of the restriction is derogated, even if for a limited time period, allowing the time and resources to investigate and test alternatives. The participating downstream users' market could be around 44% lower than the estimated baseline, with an annualised turnover loss in this situation estimated to be €112.7 billion between 2024 and 2042.

In a scenario with predefined time-limited derogations of 6.5 and 13.5 years (Scenario 2), the participating downstream users' market could be around 28% lower than the estimated baseline, which over time, and taking into account the scope for derogation reported in the consultation and the timelines that would be defined

for each sector, could lead to an annualised turnover loss of €30.9 billion between 2024 and 2042, according to the surveyed sample.

In a scenario with narrower scope of derogations (Scenario 3), companies would be more limited in the products they could continue to place on the market. They therefore may have less time and resources to adapt, attaining a lower level of substitution. As a result, by 2042 their market could be 37% lower than the estimated baseline, which over time could lead to an annualised turnover loss of €61.4 billion between 2024 and 2042.

Survey participants provided their expectation of attainable levels of derogation, as a percentage of their affected portfolio of products, in each of the two Scenarios. These were combined with an estimation of the proportion thereof that would be subject to 6.5-year derogations and to 13.5-year derogations (split between 5 and 12-year derogations, plus a 1.5-year transition period that is granted to all upon approval of the restriction), based on information by product from Prodcom. Products left out of the scope for derogations would still need to be substituted and reformulated, and therefore, could be initially lost and later progressively recovered up to the level of the reported scope for substitution in this scenario. Resulting from the end of each of the time-limited derogations, discrete increases in turnover losses are observed 6.5 years and 13.5 years after 2025.

These effects exclude the possibility of PFAS downstream users to pass any additional regulatory burden through to their customers and the associated implications, which we refer to as 'second-order effects'. These second-order effects have been considered based on the evidence gathered through the survey to EEA PFAS downstream users' companies. Based on the data available, it is estimated that companies could pass through a share of the additional regulatory burden resulting from the legislative changes. Ultimately, the feasibility of this strategy will depend on the demand elasticity in each of the sectors.

Overall, this suggests that **although this sample of downstream users is assumed to be able to introduce mitigation measures whilst incurring additional operating and capital costs (first order effects), the extent to which they would be able to pass through some of these costs to their customers (second order effects) is unknown, and their operations and associated economic footprint may still be negatively affected. Annualised turnover losses against the baseline are estimated to range from €30.1 billion to €112.7 billion per year, on average[80], between 2024 and 2042, depending on the derogation Scenario.**

The Scenarios established for the estimation of the potential policy impacts on the turnover of participating EEA PFAS downstream users already present the implications of key uncertainties around the time required for businesses to adjust their operations and place substitutes and/or reformulated products on the market (Scenarios 1, 2 and 3). Within each of these scenarios there are other assumptions, and hence uncertainties, which could affect these estimations. In particular, the sensitivity of the results to the extent to which businesses may be able to substitute and/or reformulate has been explored. The presented results include upper bounds of substitution and other forms of innovation, known and unknown, that companies report as potentially attainable in the future and with enough time. If innovation activities were not successful, substitution would be lower, and turnover losses could be larger. Lower bounds of substitution, according to the survey, could sit between 19% (Scenario 3) and 28% (Scenario 2), while they are 50% and 66% in the upper bounds, respectively, where there is time to innovate. In Scenario 1, with no extra time from the enforcement of the restriction, companies only attain the lower bounds of substitution, i.e. the substitution that is subject to less uncertainty.

Moreover, substitution and reformulation could affect the quality and attractiveness of the products placed on the market by the participating EEA PFAS downstream users. As such, 74% of respondents indicated that the proposed restriction could have a negative or very negative impact on their competitiveness outside of the EEA over the coming 10 years. A large proportion would also expect the proposed restriction to have a negative or very negative impact on their exports (60%) and increase illicit imports (80%) within the EEA over the same period.

By application, Table 6-2 introduced the extent of the affected portfolio. Reported levels of expected substitution by application and final impact as a percentage of the overall turnover from each type of application are shown in Table 6-5 below.

[80] A net present value of turnover losses against the baseline has been calculated, and later annualised over the period to estimate 'equivalent annual losses of turnover' as a result of the legislative changes. A real discount rate of 3.5% has been employed in line with the European Commission's Better Regulation Guidelines.

Table 6-5 Estimated substitution and reformulation by type of application and final impact as a percentage of the overall turnover from each type of application.

| Type of Application | Potentially Affected Portfolio (% of total turnover from application) | Substitution and Reformulation (S1 / S2 / S3) | Potential Turnover Loss in 2021 (S1 / S2 / S3) and % of total turnover from each application |
|---|---|---|---|
| Agriculture, forestry, fishery | €0.2 billion (95%) | €0.02 billion / €0.04 billion / €0.03 billion | €0.1 billion / €0.1 billion / €0.1 billion (80% / 71% / 76%) |
| Manufacture of textiles, leather, fur | €0.1 billion (31%) | €0.1 billion / €0.1 billion / €0.1 billion | €0 billion / €0 billion / €0 billion (0% / 0% / 0%) |
| Manufacture of Personal Protective Equipment | €3 billion (72%) | €0.1 billion / €1.4 billion / €0.4 billion | €2.8 billion / €1.5 billion / €2.5 billion (69% / 38% / 62%) |
| Manufacture of plastics products, including compounding and conversion | €15 billion (31%) | €1.0 billion / €15 billion / €3.9 billion | €13.9 billion / €0.0 billion / €11.0 billion (29% / 0% / 23%) |
| Paints and coatings | €1 billion (9%) | €0.3 billion / €0.4 billion / €0.6 billion | €0.8 billion / €0.6 billion / €0.4 billion (6% / 5% / 4%) |
| Lubricants | €0.4 billion (33%) | €0.1 billion / €0.4 billion / €0.2 billion | €0.3 billion / €0.0 billion / €0.2 billion (21% / 0% / 13%) |
| Manufacture of bulk, large scale chemicals (including petroleum products) | €2.9 billion (94%) | €2.9 billion / €2.9 billion / €2.9 billion | €0 billion / €0 billion / €0 billion (0% / 0% / 0%) |
| Organic chemicals | €0.5 billion (5%) | €0.5 billion / €0.5 billion / €0.5 billion | €0 billion / €0 billion / €0 billion (0% / 0% / 0%) |
| Inorganic chemicals | €3.4 billion (32%) | €3.4 billion / €3.4 billion / €3.4 billion | €0 billion / €0 billion / €0 billion (0% / 0% / 0%) |
| Manufacture of fine chemicals | €0.5 billion (86%) | €0.5 billion / €0.5 billion / €0.5 billion | €0 billion / €0 billion / €0 billion (0% / 0% / 0%) |
| Pharmaceutical | €17.7 billion (81%) | €16.8 billion / €16.8 billion / €16.8 billion | €0.9 billion / €0.9 billion / €0.9 billion (4% / 4% / 4%) |
| Medical devices | €4.0 billion (88%) | €0 billion / €0 billion / €0 billion | €4.0 billion / €4.0 billion / €4.0 billion (88% / 88% / 88%) |
| Manufacture of electrical and electronic equipment | €14.9 billion (76%) | €2.9 billion / €6.5 billion / €14.9 billion | €12.0 billion / €8.3 billion / €0 billion (61% / 43% / 0%) |
| Electronic components | €10.3 billion (84%) | €0 billion / €0 billion / €0 billion | €10.3 billion / €10.3 billion / €10.3 billion (84% / 84% / 84%) |

| Type of Application | Potentially Affected Portfolio (% of total turnover from application) | Substitution and Reformulation (S1 / S2 / S3) | Potential Turnover Loss in 2021 (S1 / S2 / S3) and % of total turnover from each application |
|---|---|---|---|
| Computers, small and large printers, electronic and optical products | €22.5 billion (82%) | €1.1 billion / €1.1 billion / €1.1 billion | €21.4 billion / €21.4 billion / €21.4 billion (78% / 78% / 78%) |
| Medical equipment | €2.6 billion (85%) | €0.8 billion / €1.3 billion / €2.2 billion | €1.8 billion / €1.2 billion / €0.3 billion (60% / 42% / 13%) |
| Energy-related (including electrical) equipment | €1.0 billion (44%) | €0.1 billion / €0.4 billion / €1.0 billion | €0.8 billion / €0.6 billion / €0 billion (41% / 28% / 0%) |
| Other small-scale equipment | €3.7 billion (92%) | €2.1 billion / €2.1 billion / €2.1 billion | €1.7 billion / €1.7 billion / €1.7 billion (41% / 41% / 41%) |
| General manufacturing, e.g. machinery, equipment, vehicles, other transport equipment | €21 billion (77%) | €15.2 billion / €17.9 billion / €16.5 billion | €5.4 billion / €2.7 billion / €4.1 billion (20% / 10% / 15%) |
| Transport (automotive, aviation, rail, aerospace) | €9.1 billion (76%) | €8.2 billion / €9.1 billion / €8.7 billion | €0.9 billion / €0 billion / €0.4 billion (7% / 0% /4%) |
| Technical equipment for industrial use (e.g. for chemical industry) | €21.7 billion (91%) | €0.1 billion / €21.7 billion / €1.1 billion | €21.7 billion / €0 billion / €20.6 billion (90% / 0% / 86%) |
| Building and construction work | €0.2 billion (33%) | €0 billion / €0 billion / €0 billion | €0.2 billion / €0.2 billion / €0.2 billion (33% / 33% / 33%) |
| Electricity, steam, hydrogen, gas, batteries and fuel cells | €0.4 billion (64%) | €0.01 billion / €0.3 billion / €0.1 billion | €0.4 billion / €0.1 billion / €0.3 billion (62% / 22% / 55%) |
| Water supply, water treatment and sewage treatment | €1.7 billion (79%) | €1.0 billion / €1.7 billion / €1.3 billion | €0.6 billion / €0 billion / €0.4 billion (30% / 0% / 17%) |
| Research and development | €0.1 billion (80%) | €0 billion / €0 billion / €0 billion | €0.1 billion / €0.1 billion / €0.1 billion (80% / 80% / 80%) |
| Scientific R&D | €0.04 billion (93%) | €0 billion / €0 billion / €0 billion | €0.04 billion / €0.04 billion / €0.04 billion (93% / 93% / 93%) |
| Life Sciences | €0.1 billion (25%) | €0 billion / €0 billion / €0 billion | €0.1 billion / €0.1 billion / €0.1 billion (25% / 25% / 25%) |

Finally, sectoral economic output is assumed to be affected by the same proportion as turnover. GVA, however, depends on impacts not only on turnover and output, but also on intermediate consumption (or operating minus employment costs). This is considered in the next section.

### 6.3.2 Gross Value Added (GVA)

The restriction of use of selected substances in light of the proposed restriction could also lead to changes in the participating EEA PFAS downstream users' GVA. These impacts, however, are estimated to not be as significant as those for turnover, although this would depend on the ability of downstream users to pass on some of the increases in regulatory burden to their customers.

Changes in output, or turnover, and intermediate consumption have an impact on GVA. The proposed restriction is estimated to result in reductions in turnover as well as in intermediate consumption, but to a lower extent, which will lead to higher GVA. This impact on GVA would be considered as a first-order effect. Businesses, on the other hand, have the opportunity to pass on some of these additional regulatory costs or burdens to their customers, as previously stated. These second-order impacts would reduce the first-order impact or drop in GVA and, as a result, at least partially the potential turnover reductions.

It should be noted that the impact on supply chains could be significant and there are likely to be knock-on implications where alternatives are not available. An example of which would be chlor-alkali electrolysis, which requires fluoropolymer membranes. Should these membranes be unavailable and no alternative exist, there would be an impact on the ability to manufacture hydrochloric acid (HCL) and sodium hydroxide (NaOH), which would in turn result in disruptions to the value chains of e.g. paper, aluminium , steel, water treatment, detergents.

Table 6-6 outlines the estimated impacts on GVA of participating EEA PFAS downstream users for two scenarios.

Table 6-6 Estimated impacts on the GVA of the EEA surveyed PFAS downstream users beyond the baseline scenario (€ 2021)

| Scenario | Direct impacts on EEA PFAS downstream users' GVA |
|---|---|
| **Scenario 1** (No derogations) | The EEA PFAS downstream users are estimated to **lose €66.6 billion (€ 2021) of Gross Value Added each year on average** over the period 2024-2042, when compared to the baseline scenario. |
| **Scenario 2** (Time-limited derogations) | The EEA PFAS downstream users are estimated to **lose €25.1 billion (€ 2021) of Gross Value Added each year on average** over the period 2024-2042, when compared to the baseline scenario. |
| **Scenario 3** (Narrower scope for derogations) | The EEA PFAS downstream users are estimated to **lose €33.8 billion (€ 2021) of Gross Value Added each year on average** over the period 2024-2042, when compared to the baseline scenario. |

When compared to the baseline scenario, the analysis estimates that the participating EEA PFAS downstream users' GVA could decrease between €19.2 billion and €66.6 billion per year on average between 2024 and 2042. These impacts are considered direct because they exclusively affect the participating EEA PFAS downstream users' companies. **Such impacts could have knock-on repercussions on the international supply chain (indirect effects) and the wider EEA economy (induced effects), reducing the sector's contribution to GDP even further.**

Box 6-5 Knock-on effects of the PFAS restriction from surveyed downstream users to the EU economy[81].

**Total impacts on the economy: The direct, indirect and induced effects**

The increase in the GVA of the participating EU PFAS downstream users is likely to have knock-on effects on the sector's international supply chain (indirect or Type I effects). The direct and indirect effects are also

[81] Input-output tables are limited to the EU-27, and therefore knock-on effects refer only to the EU.

expected to translate into an increase in employment and thus overall compensation, which would in turn further increase consumption and have broader implications across the economy (induced or Type II effects).

The indirect and induced effects, and thus, the total impacts on the economy driven by the effects of the proposed restriction have been estimated using an Input-Output methodology. The cumulative Type I and Type II multipliers have been assumed at around 1.8 and 2.2 respectively, based on evidence on multipliers from the various DU sectors from Eurostat, national statistical databases from across Europe and expert judgment.

Based on this, **total decreases in GVA driven by the effects of the proposed restriction on the EU surveyed PFAS downstream users could range between €57.2 billion and €142.5 billion every year on average between 2024 and 2042, which would be equivalent to decreasing between 0.4 to 1.0 percentage points off the EU-27 GDP in 2021.**

Source: Ricardo analysis based on Eurostat data and a bespoke survey of PFAS downstream users.

### 6.3.3 Intermediate consumption and operating costs

Under all three scenarios, more than 90% of the downstream users surveyed for this study confirmed that they would be required to change their manufacturing processes in the next 10 years as a result of the proposed restriction. For most of those (60%), this could imply significant negative changes and they may not be able to continue operations (although this was not focussed on the respondents from a particular sector). More than 25% reported negative or very negative effects: from reducing the production capacity to dropping some lines of production, or multiple production lines and even sites. These changes carry with them cost reductions for the lost business, and new costs for the productive changes to be implemented (i.e., substitution, reformulation and product redesign, and adaptation of the manufacturing process to the new products).

Firstly, the withdrawal of products from the market would necessarily imply that companies would reduce their operating activities and, as a result, operating expenditure may fall. This reduction is likely to be proportional to turnover losses against the baseline. A reduction in overall business operations could result in a reduction in operating costs over time. For example, in 2021, an operational contraction of 10% for the sample of downstream users in all of their business scopes would have been equivalent to a reduction in intermediate consumption of around €10.3 billion.

Secondly, companies would also take action to find alternatives and/or substitutes to alleviate the estimated reduction in their business. Thus, some of the current operations would need to be adjusted for the manufacturing and placing on the market of substitutes and/or reformulated products. Further, additional administrative and compliance requirements, and/or adjusting the labelling of products, and associated costs would also be incurred.

As a result, **estimates based on the survey to downstream users suggest that an additional €8.8 billion of recurring costs could be incurred as a result of a full ban with no derogations (i.e., under policy Scenario 1), €25.8 billion of recurring costs could be incurred as a result of the proposed restriction under policy Scenario 2, and €15.1 billion under policy Scenario 3.**

Overall, intermediate consumption and operating costs per unit of turnover (i.e., unit costs) may increase. These increases in intermediate consumption and Opex would be driven by the costs of substitution and reformulation that are needed to mitigate the loss of business that restrictions could trigger. For example, Opex could be 31% lower than the baseline in Scenario 2 in 2042, compared to turnover being 44% lower, meaning that the unit cost would have increased. In Scenario 2, Opex could be 14% lower than in the baseline, while turnover could be 28% lower. In Scenario 3, Opex could be 26% lower than in the baseline, while turnover could be 37% lower.

### 6.3.4 Capital and R&D expenditure

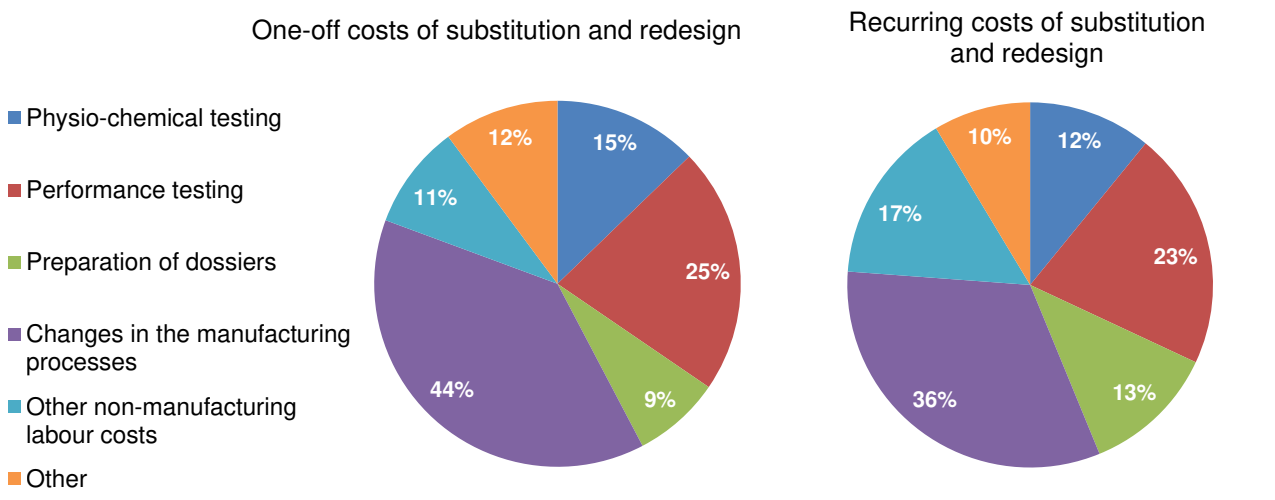
Similarly, the restriction on use of PFAS as a result of the proposed restriction could have an impact on businesses' capital and R&D expenditure. If a company's turnover shrinks, it is assumed that their overall spending will shrink as well. As an example, a 10% drop in the size of companies' turnover in the EEA might result in a corresponding reduction in overall investment, equating to €2.1 billion.

Despite the reduction in business, companies still need to invest in capital and R&D as they would need to adapt to new manufacturing processes or identify substitutes and alternative products. **Based on the survey of PFAS downstream users, it is estimated that an additional €19.3 billion in Scenario 1, additional**

**€29.1 billion in Scenario 2, and €23.7 billion in Scenario 3 (€ 2021) could be invested annually over 10-15 years from the adoption of the restriction to support the changes that their companies would need to embark on to mitigate further operational and turnover losses. For these companies, this implies an increase in Capex of between 91% and 138% for the retained business during that period**.

In the same way as with intermediate consumption, unit costs of capital are estimated to rise, at least from the adjustments to the manufacturing processes and the required investments for effective substitution, reformulation and other forms of innovation. Figure 6-10 presents the one-off and recurring costs of such activities.

Figure 6-10 Split of one-off and recurring costs of substitution, reformulation, and product redesign. Source: Ricardo survey to PFAS downstream users.




### 6.3.5 Employment

Downstream users in the sample of surveyed companies employ 3.9 million persons across the EEA in their scope of activities. The analysis estimates that restricting the use of PFAS could result in a direct net decline in jobs supported by the EEA PFAS downstream users surveyed. This decrease is mostly due to the estimated drop in the size of the PFAS downstream users' sector as a result of the proposed restriction.

The employment impact is estimated to be smaller than the turnover impact. This was determined by looking at past trends and stakeholder consultation.

Evidence on the impacts of REACH, e.g., CSES *et al*[82], suggests that additional compliance costs led to increased labour requirements in the chemicals sector, not only due to needing additional staff but also due to additional remuneration, skills, training and/or retraining costs. Similar effects upon employment could be expected within the sample of PFAS downstream users, although evidence was not collected in that respect.

**In this context, it is estimated that, by the end of 2042, around 524,500 jobs could be impacted against the baseline scenario in Scenario 1, 282,600 in Scenario 2, and 414,200 in Scenario 3, respectively, which is equivalent to 13%, 7% and 10% of the surveyed PFAS downstream users' workforce in that year, respectively.** These direct job impacts could be larger if the PFAS downstream users were unable to substitute and/or reformulate as noted in their survey responses, which would inevitably depend on a positive outcome of the innovation process and on the market response to the substituted and/or reformulated products. The possibility that job impacts are mitigated by relocation of workers to other business areas is considered and included in this result. Table 6-7 below describes the estimated average impacts on the sector's employment in the three scenarios.

[82] CSES et al (2015). *Monitoring the Impacts of REACH on Innovation, Competitiveness and SMEs*. Available from: monitoring-the-impacts-of-reach.pdf

Table 6-7 Estimated average impacts on the employment of the EEA surveyed downstream users against the baseline scenarios (jobs)

| Scenario | Estimated average impacts on employment in the sector |
|---|---|
| **Scenario 1** (No derogations) | In any given year over the period 2024-2042, sample is estimated to employ **379,100 fewer workers on average**, when compared to the baseline scenario. |
| **Scenario 2** (Time-limited derogations) | In any given year over the period 2024-2042, downstream user sectors are estimated to employ over **204,200 fewer workers on average**, when compared to the baseline scenario. |
| **Scenario 3** (Narrower scope for derogations) | In any given year over the period 2024-2042, downstream user sectors are estimated to employ over **299,500 fewer workers on average**, when compared to the baseline scenario. |

The above impacts are only considering the direct impacts as a result of the proposed restriction. However, it is assumed that a second order impact will follow, as impacts on the supply chain (indirect effects) and the wider EU economy (induced effects), leading to even larger reductions in the sector's contribution to employment.

Box 6-6 Knock-on effects of the PFAS restriction from downstream users to EU employment[83]

**Total impacts on employment: The direct, indirect and induced effects**

The impact on jobs in the EU PFAS downstream users is likely to have second-order impacts throughout the supply chain upstream (indirect or Type I effects). These direct and indirect impacts are projected to result in changes in overall compensation and, as a result, disposable income, further reducing consumption and having broader economic implications (induced or Type II effects).

Using an Input-Output technique, the indirect and induced effects, as well as the total economic consequences of the policy alternatives on the EU downstream users' sector, have been calculated. The cumulative Type I and Type II multipliers have been assumed at around 2.5 and 3.5 respectively, based on evidence from Eurostat, national statistical databases from across Europe and expert judgment.

Based on this, **the adoption of the proposed restriction could lead to a reduction of between 0.5 and 1.0 million jobs by 2042 when compared against the baseline, which would be equivalent to a reduction of between 0.2% and 0.4% percentage points off total employment in the EU-27.**

Source: Ricardo analysis based on Eurostat data and a bespoke survey of PFAS downstream users.

### 6.3.6 SME versus large enterprises

The sample of participating companies in the consultation of PFAS downstream users contains 48 SMEs (28% of the sample). Differences in how the restriction proposal is estimated to affect SMEs, as reported through the survey, can be used as illustrative or anecdotal evidence of how this subgroup of companies might be differently affected by the proposed restriction.

SMEs represent 3.5% of the total turnover from the sample of downstream users collected. When compared to larger enterprises, anecdotally, SME survey participants have a lower portfolio of products containing PFAS, of around 12% of their overall business turnover on average. At the same time, they report a level of estimated substitution and reformulation that is close to the average of the whole sample of companies (between 45% and 67%). As a result, it is estimated that **SMEs might suffer from relatively less significant turnover losses when compared with larger firms**.

[83] Input-output tables are limited to the EU-27, and therefore knock-on effects refer only to the EU.

This result may vary if some smaller companies have limited financial ability to invest in developing substitutes to their products that do not use or contain PFAS. However, responses on this account were limited and hence an analysis of the distribution of impacts on the sample of SMEs was not possible.

This result can be complemented with previous assessments of the impact of existing chemicals legislation. For example, CSES *et al*[84] highlight concerns about the increases in regulatory burden due to REACH, which may force smaller firms out of the market, or inhibit entry of new ones, and reduce the overall supplier base of the industry. The study also suggests that, given some SMEs are more innovative, such an impact could have long-lasting negative effects on the EEA chemicals sector. With respect to PFAS downstream user SMEs, however, **evidence collected from our survey participants could not conclusively support that SMEs are more (or less) innovative than larger firms, or that they would be at a higher (or lower) risk of being forced out of the market**.

More research would be needed to provide a quantification of how the policy solutions addressed in this study may influence SMEs in general. **However, their limited responses in the PFAS downstream user survey might already suggest a stretch on resources, while larger firms have provided more detailed evidence on the potential scope for substitution**.

## 6.4 QUALITATIVE CONSIDERATIONS OF THE PROPOSED RESTRICTION

Survey respondents provided additional qualitative inputs to the consultation. These have been analysed and summarised below.

In general, both manufacturers/ importers and downstream users are supportive of further regulation of PFAS as they acknowledge that there is a need to address the environmental, and in some cases human health, impacts that certain PFAS pose. There is consensus across respondents that the current PFAS proposal (RO2 in the Annex XV report) has a chemical scope which is too wide due to the differences in environmental and human health effects of PFAS and the criticality of certain substances within sectors that ensure the functioning of society and help to meet EU objectives such as the Green Deal and twin transitions. Concern also exists with regard to the scope of the time-limited derogations, which, in some cases, do not appear to reflect the true availability of alternatives. Some have also raised concerns related to global competitiveness of EU companies and the impact such a restriction could have on the strategic autonomy of the EU.

Some manufacturers have raised concerns with the lack of derogation for intermediates, which could have a significant impact on the manufacture of other chemicals in which the PFAS are not contained in the final product, such as active pharmaceutical ingredients (APIs).

The impact of the proposed restriction is wider reaching than the direct impacts related to loss of products containing PFAS. PFAS are used in the manufacturing processes and machinery for a large number of critical products, without being present in the final product. Fluoropolymer-based sealing devices (such as shaft seals, gaskets, O-rings) and lubricants are critical to a number of applications due to their unique properties, including high chemical resistance; thermal stability; low coefficient of friction; flame resistance; insolubility; excellent weatherability; and purity. Without such products, any manufacturing that is subject to harsh conditions or requires ease of cleaning and sterility may not be possible. As an example, in the case of harsh manufacturing conditions or the use of hazardous substances, fluoropolymer-based sealing devices are critical for ensuring the protection of human health and the environment from leakage of hazardous substances. In the pharmaceutical and life sciences fields, special purpose membranes surface-treated with PFAS (e.g. vents) ensure the continuous operation of drug and vaccine development and guarantee high quality sterility tests prior to the placing of pharmaceuticals on the market. If such products were no longer available as a result of the restriction of PFAS, manufacturers of biomedical therapies and medical devices would need to redesign their test methods and protocols, qualify new fluid-path material and change sterilisation methods all of which would require many years of investment and certification. As a large number of these products are made in the EEA, there could be a significant unintended impact on the global availability of pharmaceuticals, including vaccines.

Water treatment with ozone is required for certain applications, including the pharmaceutical, semiconductor and other high-tech industries. Such treatment methods require the use of proton exchange membranes (PEM) based on perfluorinated copolymers, which allow for water circulation systems to be kept germ-free even when

[84] Ibid. footnote 82.

systems are not run continuously. Consideration and investment in alternatives exist but are either still in their infancy or are not considered economically or ecologically sustainable (thermal treatment).

High-tech electronics could be significantly impacted by the PFAS restriction. The semiconductor industry directly relies on PFAS for plasma etching, chamber cleaning, photolithography, anti-reflective coatings, as well as for e.g. sealing devices, lubricants and temperature control fluids in the manufacturing machinery itself. Vapour phase technology is an alternative soldering process in the electronics industry, with advantages such as no overheating or delamination, lower energy consumption and a smaller footprint required for production facilities. It is being used in the manufacture of high-tech electronics such as electric vehicles, renewable energy, batteries, power converters, satellites and aircraft. Membrane electrode assemblies require the use of fluoropolymers and have applications in hydrogen, fuel cell and water electrolyser technologies. These are just three examples of high-tech electronics which are required for the EU to meet the ambitions of the Green Deal. Should the PFAS restriction enter into force without derogations that allow for research and development into alternatives, the ability of the EU to meet its own ambitions could be hindered.

This is highlighted by the large majority **(85%) of survey respondents stating there are no viable alternatives for their PFAS uses available on the market that have the same properties and technical function**. The remaining respondents say there are viable alternatives to PFAS that exist on the market today and that can be used in their products.

For downstream applications in the *manufacture of electrical and electronic equipment*, it is argued that a high number of their applications do not have alternative products and would not be available to consumers. They also note that those products with alternative substances currently available, may be more costly, less efficient and have higher failure rates. Also, they note that products may present safety concerns due to flammability.

Similarly, *manufacturers of electronic components* argue that products containing PFAS or that use PFAS in the manufacturing process will have become significantly less functional or reliable. Thus, they argue that products will have a shorter service life, will be less efficient and won't be able to meet quality and safety standards (e.g. UL94-V0).

For the *manufacture of machinery, equipment, vehicles, other transport equipment*, respondents highlight examples of major failures in nuclear power plants, and digital infrastructure as the result of using alternative substances in their manufacturing processes. Also, **higher prices** and **unavailability of certain products** are brought forward as arguments.

Among *manufacturers of technical equipment for industrial use*, there is the expectation of an increase in the price of products, that in most cases would be passed-through consumers, coupled with a shorter product service life. They argue that electrical safety will be affected, and there will be more leakages.

Producers of *water supply and treatment products* claim that product alternatives require more capital and have larger ecological footprints (increased waste generation). They also highlight that some critical products, e.g. for hygiene application in water treatment would not available after the restriction (e.g. dosing pumps for biocides). According to the respondents, there will be a loss of product safety and quality coupled with increasing costs and a shorter service life.

PFAS are used in medical devices and equipment for a number of reasons, namely for their low surface tensions coatings, their use as contrast agents in medical imaging, and as oxygen carriers due to their effective ability to dissolve gases[26]. However, these are not the only functions of PFAS in medical devices, and some PFAS applications have been cited as not having comparable alternatives. For example, it was stated in the consultation that there are **no alternatives available** providing comparable relief for Dry Eye Disease (DED) patients. Furthermore, downstream users also indicated in the consultation that there are a lack of alternatives for medical devices with antithrombogenic surface activity, as well as pharmaceutical and biopharmaceutical manufacturers relying on products containing PFAS for the assurance of drug and vaccine sterility prior to market release.

Companies were also asked how many new products they have tried bringing to the market but failed doing so; on average, they report having failed to bring between 12 and 15 products to the market in the past, and this ranges from less than 5 to more than 20 failed alternatives to their products. It is noted that these are just examples as not all respondents answered this question. Among the most common reasons for alternatives to have failed, according to respondents, are performance (e.g., durability, resistance) (28% of respondents) and regulatory costs (e.g. testing, approvals, standards) (22% of respondents).

**It should be noted that an analysis of alternatives was outside of the scope of this Study and so claims made by industry on availability of alternatives and the potential impacts on product availability and function cannot be corroborated. This topic will be subject to a separate Cefic study.**

Although R&D efforts are considered to be vital for companies to mitigate the impacts of the proposed restriction, respondents have noted that where large parts of their portfolio are affected, they may not have the resources (capital and time) available to be able to carry out R&D at such a large scale. These efforts would require not only investment in the products themselves, but also in the machinery used in their production, which could result in capital expenditures that are too high to be feasible. This may force companies to abandon certain product lines as they cannot carry out all of the R&D efforts within the time-limited derogation period. Changes to manufacturing machinery also tends to be outside of the remit of a downstream user and so would require their supplies to invest in such changes.

When asked about other manufacturing changes that would be needed to continue production in light of the proposed restriction, 90% of respondents have indicated they would need to change their manufacturing processes in the EEA to comply in the next 10 years. Among those, 58% indicate they would have to implement significant negative changes (drop from 1-2 various production lines and/or sites) in order to comply with the introduction of the proposed restriction in the next 10 years. Another 26% have stated they would have to implement some negative changes, reducing their production capacity on some lines or sites. Among the remaining, 13% say they would have to implement limited negative changes (portfolio of PFAS is not very relevant to their overall production, but it would decrease). Around 3% say they do not know the impact of changes.

Manufacturers and importers noted that the PFAS restriction could risk relocation of production outside of the EU, which would not only affect the strategic autonomy of the EU but also increase capital investments abroad. Respondents have also highlighted that the proposed restriction could have far-reaching consequences to manufacturing sites and businesses based elsewhere, like the UK, Asia and America, which the questionnaire does not capture. The disproportionate approach of restricting all PFAS under the same criteria, while they have many different toxicological profiles, would interfere with basic guideline on setting up regulations and may lead to jurisdictional disputes, absorbing capacities within industry and legislative authorities as well. Regulatory uncertainty would lead to imponderability for the industry, ending up in delayed investments or even shift of business activities to non-EU countries.

There is also a need to consider impacts on trade. With respect to exports, 60% of respondents agree that the proposed restriction would negatively impact the production being exported from the EEA, while 60% say it will additionally have an impact on products that they import into the EEA.

With regard to illicit imports, 80% of respondents indicate they would expect to see an increase in illicit imports of professional and consumer products into the EEA over the next 10 years as a result of a decrease in product availability. Overall, in terms of competitiveness, 74% of respondents say they think the implementation of a PFAS restriction in the EEA would have a negative or very negative effect on the competitiveness of the industry, under all policy scenarios.

# 7. CONCLUSIONS

This Study sought to assess the business impact to a sample of manufacturers, importers and downstream users of PFAS as a result of the proposed REACH restriction of PFAS. The analysis suggests that the proposed restriction is likely to have **significant impacts on EEA PFAS manufacturers and importers, downstream users and the wider economy**.

## 7.1 METHOD AND SCENARIOS ASSESSED

To assess the net impacts of this policy on the EU PFAS manufacturers and importers, and downstream users, a baseline and three policy scenarios were developed:

- The sectoral **baseline** (2021-2040) was developed by aggregating evidence of turnover and growth expectations elicited in the survey to PFAS manufacturers and importers, and the participating downstream users. This baseline scenario assumes that the proposed restriction of PFAS is not implemented.
- A first policy scenario (**Scenario 1**) considers that the proposed REACH restriction on the manufacturing, placing on the market and use of PFAS is implemented in full and no derogation is applicable. This includes a transition pathway of 1.5 years until effective implementation. The restriction implies an immediate loss of portfolio that is followed by mitigatory strategies by PFAS manufacturers and downstream users, such as substitution, reformulation and other forms of innovation. As products that use PFAS are affected by the proposed restriction, they will need to be redesigned with new substances, formulas and/or processes.
- A second policy scenario (**Scenario 2**) considers that the proposed REACH restriction on the manufacturing, placing on the market and use of PFAS, is implemented following Restriction Option 2 (the preferred option) as published in the Annex XV report on 7 February 2023. This includes a transition pathway of 1.5 years until effective implementation. The restriction is followed by mitigatory strategies by PFAS downstream users, such as substitution, reformulation and other forms of innovation. As products are affected by the proposed restriction, they will need to be redesigned with new substances, formulas and/or processes. Derogations are implemented according to the restriction proposal, with either a 6.5-year derogation or a 13.5-year derogation affecting only certain applications or products within each sector. Once the time-limited derogations cease, affected products could no longer be placed on the market unless they are substituted and/or reformulated.
- A third scenario (**Scenario 3**) considers that the proposed REACH restriction on the manufacturing, placing on the market and use of PFAS is implemented with a more limited scope for derogation than in Scenario 2. This includes a transition pathway of 1.5 years until effective implementation.

The evidence collated from the two surveys was overlayed with an expected reasonable policy implementation timeline. In essence, this step assigns the reductions in the EEA PFAS manufacturer, importer and downstream user sector's product portfolio to the moment or moments in which the proposed restriction would enter into force (i.e., first effective implementation, and potential time-limited derogations for some uses). No business response, e.g., substitution, is considered before that time. By the end of the period of assessment (2042), the size of the products in scope of the restriction proposal have been affected by the regulatory change and all potential mitigatory actions have taken place and effects materialised.

## 7.2 FINDINGS

**Turnover from PFAS manufacture and import is estimated to be reduced by almost the whole value of their PFAS portfolio, up to 91% of their total, wider business scope's turnover**, if the proposed restriction is implemented. Information reported in consultation with PFAS manufacturers and importers suggests that the scope of substitution and reformulation strategies amongst PFAS manufacturers/ importers may be limited and below 10% of the portfolio of PFAS in terms of turnover. Therefore, in annualised terms, the surveyed **EEA PFAS manufacturers and importers are estimated to lose €3.5 billion (€ 2021) of turnover each year on average over the period 2024-2042, when compared to the baseline scenario if there were no derogations (Scenario 1)**, and **between €2.1 and €2.9 billion per year on average in Scenario 2**, and **between €2.5 and €3.0 billion per year on average in Scenario 3**. The low scope for substitution and reformulation reported by PFAS manufacturers and importers does not mean that there will be no alternatives;

rather, it is expected that alternative products and technologies without PFAS may be developed by other actors in the chemicals sector who have the required manufacturing facilities and also in other sectors, directly as alternatives to the current applications. This has been indeed clarified by some respondents, as this development would not be in the scope of activities of PFAS manufacturers and/or importers at present, but could happen further down the value chain. To note, it has not been possible to estimate the benefits to the alternatives manufacturers of the proposed restriction but it is acknowledged that a level of benefit could be expected where alternatives can be developed that do not rely on PFAS for their manufacture and where the environmental and human health hazards are not of similar concern.

**For participating PFAS downstream users, the size of the 'total potentially affected product portfolio' was estimated to be around 63% of the turnover from PFAS downstream users in our consultation, which would be equivalent to €159 billion in 2021** out of a total turnover of €254 billion. That means that 63% of participating PFAS downstream user companies' income comes from products that contain PFAS or require PFAS for their production. Evidence collected for this study suggests that, in response to the affected portfolio that may be restricted (63% of the total PFAS downstream users' portfolio), downstream users may be able substitute and/or reformulate a significant proportion of that portfolio, , with central estimates, averaged and weighted across sectors, for substitution and reformulation of 37% of the affected portfolio under Scenario 1, 66% of the affected portfolio under Scenario 2, and 50% under Scenario 3. This would allow them to mitigate market losses, although this will depend on having the time and resource to innovate, on a positive market uptake and on whether the alternative products maintain the same function. Therefore, this means that the proposed restriction, when accounting for potential business responses, could lead to a **reduction in product portfolio and business (in turnover terms) with central estimates of 40% (Scenario 1), 21% (Scenario 2), and 31% (Scenario 3) of PFAS downstream users' portfolios, resulting in annualised losses of between €30.9 and €112.7 billion (€ 2021[85]) of turnover each year on average** over the period 2024-2042, when compared to the baseline scenario.

The portfolio losses estimated for PFAS manufacturers and importers, and for the participating PFAS downstream users, are estimated to be accompanied by proportional reductions in operating expenditure and regulatory burden, although additional expenditure and investment are assumed in order to develop new products and alternatives. For manufacturers and importers, the limited scope of potential mitigation strategies could result in a **reduction of the sector's contribution to the EU GDP (i.e., the sector's Gross Value Added, GVA) of €1.5 billion per year on average between 2024 and 2042 in a Scenario 1 with no derogations, and by €0.9-1.2 billion in Scenario 2, and by €1.0-1.3 billion in Scenario 3**. Such impacts could have knock-on repercussions on the international supply chain (indirect effects) and the wider EU economy (induced effects), potentially reducing the sector's contribution to GDP even further. **Total decreases in GVA driven by the effects of the proposed restriction on the EEA PFAS manufacturers and importers are estimated to be €4.9 billion every year on average between 2024 and 2042 in Scenario 1, €3.0-4.1 billion every year on average between 2024 and 2042 in Scenario 2, and in Scenario 3, total GVA decreases could range from €3.5-4.3 billion every year on average, which would be equivalent to a decrease of 0.02-0.04% in the EU-27 GDP (using 2021 as reference year).**

For surveyed downstream users, substitution and reformulation strategies require operational and capital expenditures to develop mixtures and articles with alternative formulations or substances to PFAS. As a result, they are estimated to experience GVA losses over the period 2024-2042 of between €25.1 and €66.6 billion each year on average against the baseline. **Total decreases in GVA driven by the effects of the proposed restriction on the EEA sample of PFAS downstream users are estimated to be between €57.2 billion and €142.5 billion every year on average between 2024 and 2042, which would be equivalent to decreasing between 0.4 to 1.0 percentage points off the EU-27 GDP in 2021.**

Portfolio losses may also materialise into disinvestments for PFAS manufacturers and importers, with production lines associated with PFAS being dropped. This could mean that **capital expenditure related to PFAS manufacture and import is estimated to fall by around €900 million per year in Scenario 1, between €600 and €800 million per year between 2023 and 2042 in Scenario 2, between €700 and €800 million per year between 2023 and 2042 in Scenario 3, in annualised terms against the baseline**. Capex or R&D expenditure associated with products that could be discontinued as a consequence of the regulatory changes may be unlikely to be retained in the EEA; it might be developed elsewhere, although only anecdotal evidence on this could be collected in the form of opinions by manufacturers. **From the side of the**

[85] All monetary quantities are isolated from the effects of inflation and expressed in real euros of 2021, as indicated by '€ 2021'.

**participating PFAS downstream users, an additional €19.3 billion in Scenario 1, additional €29.1 billion in Scenario 2, and €23.7 billion in Scenario 3 (€ 2021) could be invested annually over 10-15 years** from the adoption of the restriction to support the changes that their companies would need to embark on to mitigate further operational and turnover losses. For these companies, this implies an increase in Capex of between 91% and 138% for the retained business during that period.

The proposed restriction could also affect the sector's employment. It is estimated that, **by the end of 2042, around 14,300 jobs could be impacted against the baseline scenario in any Scenario, which is equivalent to 30% of the surveyed PFAS manufacturers' workforce in that year**. This high number of job impacts is attributed to the fact that PFAS manufacturers do not expect to be able to retain a large part of their business by reformulating and substituting PFAS products, although the possibility that job losses are mitigated by relocation of workers to other business areas is considered and included in this result. In the case of participating PFAS downstream users, **by the end of 2042, around 524,500 jobs could be impacted against the baseline scenario in Scenario 1, 282,600 in Scenario 2, and 414,200 in Scenario 3, respectively, which is equivalent to 13%, 7% and 10% of the surveyed PFAS downstream users' workforce in that year, respectively.**

Table 7-1 below summarises some of these impacts on key business and economic indicators of the PFAS producing and importing sector against the baseline.

Table 7-1 Annualised impacts on selected business and economic indicators of the EEA PFAS manufacturing and producing sector, against the baseline scenario (€ 2021)

| Themes (business or economic indicators) | Scenario 1 (No derogations) | Scenario 2 (Time-limited derogations) | Scenario 3 (Narrower scope for derogations) |
|---|---|---|---|
| Turnover (first order effects) | A loss of €3.5 billion per year between 2024 and 2042 on average against the baseline | A loss of between €2.1 and €2.9 billion per year between 2024 and 2042 on average against the baseline | A loss of between €2.5 and €3.0 per year between 2024 and 2042 on average against the baseline |
| Total GVA contribution (*direct, indirect, induced*) | A loss of €4.9 billion per year between 2024 and 2042 on average against the baseline | A loss of €3.0-4.1 billion per year between 2024 and 2042 on average against the baseline | A loss of €3.5-4.3 billion per year between 2024 and 2042 on average against the baseline |
| Total employment contribution (*direct, indirect, induced*) | 32,700 impacted jobs, on average, when compared to the baseline in any given year between 2024 and 2042 | 27,300 impacted jobs, on average, when compared to the baseline in any given year between 2024 and 2042 | 28,700 impacted jobs, on average, when compared to the baseline in any given year between 2024 and 2042 |

Table 7-2 below summarises some of these impacts on key business and economic indicators of the participating PFAS downstream users against the baseline.

Table 7-2 Annualised impacts on selected business and economic indicators of the participating EEA PFAS downstream users, against the baseline scenario (€ 2021)

| Themes (business or economic indicators) | Scenario 1 (No derogations) | Scenario 2 (Time-limited derogations) | Scenario 3 (Narrower scope for derogations) |
|---|---|---|---|
| Turnover (first order effects) | A loss of €112.7 billion per year between 2024 and 2042 on average against the baseline | A loss of €30.9 billion per year between 2024 and 2042 on average against the baseline | A loss of €61.4 billion per year between 2024 and 2042 on average against the baseline |
| Total GVA contribution (*direct, indirect, induced*) | A reduction of €142.5 billion per year between 2024 and 2042 on average against the baseline | A reduction of €57.2 billion per year between 2024 and 2042 on average against the baseline | A reduction of €78.4 billion per year between 2024 and 2042 on average against the baseline |
| Total employment contribution (*direct, indirect, induced*) | 863,200 impacted jobs, on average, when compared to the baseline in any given year between 2024 and 2042 | 464,900 impacted jobs, on average, when compared to the baseline in any given year between 2024 and 2042 | 682,000 impacted jobs, on average, when compared to the baseline in any given year between 2024 and 2042 |

Finally, substitution and reformulation could affect the performance, quality and attractiveness of the mixtures, articles and/or products placed on the market by the participating EEA PFAS downstream users. **PFAS provide a variety of special properties to the products they are used in, and as such, those properties might not be fully replicated by alternative substances, mixtures and articles. Increased costs and reduced efficiency in the performance of the alternatives could lead to increased burden on consumers, possibly limiting their choice and increasing illicit trade of non-compliant products**.

The impacts estimated on the PFAS manufacturers and importers and PFAS downstream users that were consulted in this Study show that largest net product portfolio withdrawals and, thus, turnover losses could primarily occur at the manufacturing/importing stage of the PFAS value chain, in relative terms. Further downstream, the consulted businesses have suggested that they would be able to partially mitigate the effects of the restriction through the development of substitutes and alternatives. However, this would also imply large economic losses in absolute terms (already €30.9 billion lost per year when derogations are considered, and only for the surveyed sample). Whilst the extent of possible substitution and reformulation is uncertain and highly dependent on the available time and resources to innovate, according to the PFAS downstream users engaged in the consultation, they would be able to draw on alternative formulas and/or technologies to produce their products without PFAS for between 37% and 66% of the affected portfolio of products in terms of turnover. However this is highly uncertain and dependent on the evidence provided by the participants to the consultation for this Study. Overall estimated impacts remain significant even in the most optimistic scenario for substitution, with 13.5-year derogations. It should be noted that the impact on supply chains could be significant and there are likely to be knock-on implications where alternatives are not available. An example of which would be chlor-alkali electrolysis, which requires fluoropolymer membranes. Should these membranes be unavailable and no alternative exist, there would be an impact on the ability to manufacture hydrochloric acid (HCL) and sodium hydroxide (NaOH), which would in turn result in disruptions to the value chains of e.g. paper, aluminium , steel, water treatment, detergents.

# APPENDICES

# Appendix 1 Additional Policy Context

This appendix presents additional policy context to on derogations from restrictions on use of PFAS

Table 7-3 Derogations for PFOA under Annex I of the POPs Regulation

| Use | Deadline |
|---|---|
| Photolithography or etch processes in semiconductor manufacturing | 4 July 2025 |
| Photographic coatings applied to films | 4 July 2025 |
| Textiles for oil- and water-repellency for the protection of workers from dangerous liquids that comprise risks to their health and safety | 4 July 2023 |
| Invasive and implantable medical devices | 4 July 2025 |
| Manufacture of polytetrafluoroethylene (PTFE) and polyvinylidene fluoride (PVDF) for the production of:<br>high-performance, corrosion-resistant gas filter membranes, water filter membranes and membranes for medical textiles;<br>industrial waste heat exchanger equipment;<br>industrial sealants capable of preventing leakage of volatile organic compounds and PM2.5 particulates | 4 July 2023 |
| Fire-fighting foam for liquid fuel vapour suppression and liquid fuel fire (Class B fires) already installed in systems, including both mobile and fixed systems | 4 July 2025 |
| Producing pharmaceutical products | Subject to review and assessment |
| Articles already in use before 4 July 2020 | N/A |

Table 7-4 Derogations under Entry 68 of REACH Annex XVII

| Use | Deadline | Concentration Limit |
|---|---|---|
| Textiles for oil- and water-repellency for the protection of workers from dangerous liquids that comprise risks to their health and safety | 4 July 2023 | N/A |
| Manufacture of polytetrafluoroethylene (PTFE) and polyvinylidene fluoride (PVDF) for the production of:<br>high performance, corrosion resistant gas filter membranes, water filter membranes and membranes for medical textiles;<br>industrial waste heat exchanger equipment;<br>industrial sealants capable of preventing leakage of volatile organic compounds and PM 2.5 particulates | 4 July 2023 | N/A |
| Semiconductors on their own | 31 December 2023 | N/A |
| Semiconductors incorporated in semi-finished and finished electronic equipment | 31 December 2023 | N/A |
| Photolithography or etch processes in semiconductor manufacturing | 4 July 2025 | N/A |
| Photographic coatings applied to films | 4 July 2025 | N/A |
| Invasive and implantable medical devices | 4 July 2025 | N/A |
| Fire-fighting foam for liquid fuel vapour suppression and liquid fuel fire (Class B fires) already installed in systems, including both mobile and fixed systems, subject to the following conditions:<br>• fire-fighting foam that contains or may contain C9-C14 PFCAs, their salts and C9-C14 PFCA-related substances shall not be used for training; | 4 July 2025 | N/A |

| Use | Deadline | Concentration Limit |
|---|---|---|
| • fire-fighting foam that contains or may contain C9-C14 PFCAs, their salts and C9-C14 PFCA-related substances shall not be used for testing unless all releases are contained;<br>• from 1 January 2023, uses of fire-fighting foam that contains or may contain C9-C14 PFCAs, their salts and C9-C14 PFCA-related substances shall only be allowed to sites where all releases can be contained;<br>• fire-fighting foam stockpiles that contain or may contain C9-C14 PFCAs, their salts and C9-C14 PFCA-related substances shall be managed in accordance with Article 5 of the POPs Regulation ((EU) 2019/1021) | | |
| Pressurised dose-metered inhalers | 25 August 2028 | N/A |
| Semiconductors used in spare or replacement parts for finished electronic equipment placed on the market before 31 December 2023 | 31 December 2030 | N/A |
| Fluoroplastics and fluoroelastomers | 25 August 2024 | 100 ppb |
| PTFE micro powders produced by ionising irradiation or by thermal degradation, as well as in mixtures and articles for industrial and professional uses containing PTFE micro powders | N/A | 1,000 ppb |
| Articles placed on the market before 25 February 2023 | N/A | N/A |

Table 7-5 Use categories of PFAS applications. The parentheses numbers indicate the number of sub-categories contained.[86]

| | |
|---|---|
| Aerosol propellants | Metallic and ceramic surfaces |
| Air conditioning | Music instruments (3) |
| Antifoaming agent | Optical devices (3) |
| Ammunition | Paper and packaging (2) |
| Apparel | Particle physics |
| Automotive (12) | Personal care products |
| Cleaning compositions (6) | Pesticides (2) |
| Coating, paints, and varnishes (3) | Pharmaceuticals (2) |
| Conservation of books and manuscripts | Pipes, pumps, fittings, and line |
| Cook and baking ware | Plastic, rubber, and resins (4) |
| Dispersions | Printing (4) |
| Electronic devices (7) | Refrigerant systems |
| Fingerprint development | Sealants and adhesives (2) |
| Fire-fighting foam (5) | Soldering (2) |
| Flame retardants | Soil remediation |
| Floor covering including carpets and floor polish | Sport article (7) |
| Glass | Stone concrete and tile |
| House applications | Textile and upholstery (2) |
| Laboratory supplies, equipment, and instrumentation (4) | Tracing and tagging (5) |
| Leather (4) | Water and effluent treatment |

[86] Ibid footnote [26]

| | |
|---|---|
| Lubricants and greases (2) | Wire and cable insulation, gaskets, and hoses |
| Medical utensils (14) | |

# Appendix 2 Methodology

This appendix provides additional details of the methodology employed for the assessment of business impacts and knock-on economic effects that could potentially result from the implementation of the universal restriction of PFAS, which were covered in Section 6. In particular, three aspects are explored:

- Baseline estimations
- Knock-on effects to the wider economy
- Annualization of impacts

## Baseline estimation

This study defined and characterised how the sample of EEA PFAS manufacturers, importers and downstream users would likely evolve without any further policy changes in EEA Chemicals legislation, drawing from the EC's Better Regulation Toolbox. This includes:

- Defining the **'Do nothing' policy scenario**, that is, what the EEA Chemicals legislation would look like in the absence of the CSS;
- Identifying key economic and sectoral indicators that can be used to characterise the potential evolution of the **sample of EEA PFAS manufacturers, importers and downstream users;** and
- Quantifying how these indicators may evolve over a period of 20 years (2020-2040).

First, policy experts from the study team defined what the 'Do nothing' scenario would look like in terms of EEA Chemicals legislation. In particular, the study team experts confirmed the existing legislation and the legislative changes that are already expected for implementation over the period without the need for the EC to take any further legal action.

From a business perspective, it was assumed that the existing framework would continue broadly as-is over the period, which would include periodical harmonised classification and labelling (CLH) updates to the CLP Regulation and subsequent poison centre notification (PCN) updates.

Secondly, the team established a set of indicators of focus to characterise the baseline of the EEA Chemicals sector and the EEA economy, which would become the quantitative baseline against which the policy options would be assessed. Table 7-6 below outlines the selected indicators, based on their relevance and the evidence available from Cefic and Eurostat.

Table 7-6 Sectoral indicators selected for baseline characterisation[87]

| Theme | Indicators |
|---|---|
| GDP and growth | • Sectoral output or production value or turnover (€ billions)<br>• Turnover from exports (€ billions) – only general Chemicals sector<br>• Sectoral Gross Value Added (€ billions), approximately capturing the sector's contribution to Gross Domestic Product)<br>• Gross investment (€ billions)<br>• Operating expenditure (€ billions)<br>• Research and Development expenditure (€ billions) |
| Regulatory burden | • One-off or recurring regulatory costs (€ billions) |

[87] International trade and competitiveness were not quantitatively assessed due to the study's scope and limited availability of evidence and, therefore, a detailed baseline characterisation was not carried out at this stage.

| Theme | Indicators |
|---|---|
| Employment | • Number of jobs supported by the sector (Number of jobs) |

Historical evidence and data were collated from multiple, publicly available sources. Table 7-7 provides an overview of these sources for each indicator.

Table 7-7 List of economic indicators and statistics used in the definition of a baseline and analysis of impacts

| Indicator | Scope | Sources |
|---|---|---|
| Turnover | • Geo: EEA<br>• Time: 2008-2019<br>• Sector: chemicals sector (NACE Rev. 2 Code C20)<br>• Turnover from exports | • Eurostat Structural Business Statistics<br>• Cefic Facts and Figures 2023<br>• Cefic Facts and Figures 2023 - Country reports<br>• Eurostat Trade by NACE Rev. 2 activity sector (ext_tec09) |
| Gross Value added (GVA) | • Geo: EEA<br>• Time: 2008-2019<br>• Sector: chemicals sector (NACE Rev. 2 Code C20) | Eurostat Structural Business Statistics |
| Intermediate consumption/ Opex | • Geo: EEA<br>• Time: 2008-2019<br>• Sector: chemicals sector (NACE Rev. 2 Code C20) | Eurostat Structural Business Statistics |
| Capital expenditure | • Geo: EEA<br>• Time: 2008-2019<br>• Sector: chemicals sector (NACE Rev. 2 Code C20) | Eurostat Structural Business Statistics |
| R&D | • Geo: EEA<br>• Time: 2008-2019<br>• Sector: chemicals sector (NACE Rev. 2 Code C20) | Cefic Facts and Figures 2023 and Country Reports |
| Regulatory burden | • Geo: EEA<br>• Time: 2008-2019<br>• Sector: chemicals sector (NACE Rev. 2 Code C20) | Cefic Facts and Figures 2023 and Country reports |
| Employment | • Geo: EEA<br>• Time: 2008-2019<br>• Sector: chemicals sector (NACE Rev. 2 Code C20) | • Eurostat Structural Business Statistics<br>• Eurostat LFSI_EMP_A |
| GDP | • GDP historic series and baseline projections for EEA countries (2020-2040)<br>• GDP deflator historic series and baseline projections for EEA countries (2020-2040)<br>• Population historic series and baseline projections for EEA countries (2020-2040) | • OECD long-term macroeconomic projections[88]<br>• Eurostat NAMA_10<br>• Eurostat NAIDA_10<br>• European Commission – Spring 2021 Economic Forecast |

[88] OECD, (2018) *GDP Long-term forecast (indicator)*, [Online] doi: 10.1787/d927bc18-en, Available from: https://data.oecd.org/gdp/gdp-long-term-forecast.htm

Some data gaps were identified, which rendered the data series incomplete for some of the economic indicators at the EEA chemicals sector level. These gaps were addressed by employing data available at the sub-sector and country levels for EEA and employing trend analysis or other reasonable assumptions to address said gaps.

Once a historical dataset was completed based on the best evidence available and expert input, regression analysis techniques were employed to estimate sectoral turnover over the next two decades (2020-2040). A pooled Ordinary Least Squares model was specified to quantify the historical relationships between sectoral turnover (the dependent variable) and real GDP growth, population growth and a time trend (the independent variables).

These estimated relationships were coupled with projections of real GDP capita and population by public institutions such as Eurostat and the OECD to produce turnover projections.

All other selected variables were estimated based on their relationship with turnover, as summarised in the Table below.

Table 7-8 Baseline projection of the other, selected indicators

| Indicator | Method of projection |
|---|---|
| Output/ production value | Economic output or production value projections are computed as a proportion of turnover, based on the average historic ratio of turnover to economic output/production value from 2008-2018. |
| Gross Value added (GVA) | GVA projections are developed from the difference between production value and intermediate consumption. |
| Intermediate consumption/ Opex | Intermediate consumption is estimated based on the extrapolation of the historical trend of intermediate consumption per unit of production. The cumulative growth of intermediate consumption per unit of production over the period 2008-2018 is assumed to continue, only more spread over time, for 2019-2040. Opex is assumed to follow similar annual growth as intermediate consumption. |
| Capital expenditure | Capital expenditure is estimated based on the historical average capex per unit of turnover from 2008-2018. |
| R&D | R&D expenditure is estimated to follow a similar growth pattern as turnover, although this is likely to be conservative. |
| Regulatory burden | Baseline regulatory burden is expected to remain constant as a % of turnover, based on Technopolis Group, VVA. (2016) and Cefic Facts & Figures reports. |
| Employment | Number of employees is computed by assuming a relatively constant relationship in employment per unit of turnover, whilst taking into account employment stickiness observed in the past (i.e., slower downward adjustments, based on historical evidence and the evidence collected through a bespoke survey). |

The resulting growth rates were applied to the sample current (2019) baseline as reported by PFAS manufacturers, importers and downstream users in consultation, thus obtaining future baseline estimations for the period 2019-2040.

## Knock-on effects to the wider economy and Input-Output methodology

The indirect and induced effects, and thus, the total impacts on the economy driven by the effects of the policy options on EEA PFAS manufacturers, importers and downstream users consulted have been estimated using an Input-Output methodology.

First, GVA measures the contribution that the EEA PFAS manufacturers, importers and downstream users consulted make to the economy. The two methods of measuring GVA used in this analysis are:

- The production approach that estimates the value of the goods and services produced minus the value of inputs into their production (such as raw materials)
- The income approach that determines the incomes earned by businesses and workers in producing these goods and services

Secondly, the total impact of a policy change in the sectoral GVA equals the sum of:

- Direct impact, that is, the immediate effect of a policy change on the sectoral production and, thus, its value added; and
- Indirect impacts, that is, any impacts on the sector's value chain, which would be reflected in changes to the intermediate demand for inputs to other sectors; and
- Induced impacts, that is, knock-on effects on the broader economy attributed to how the direct and indirect effects may result in changes to the compensation of employees, which would cause further changes in final demand and spending throughout the whole economy.
- The direct effects have been estimated by drawing on a survey of businesses and publicly available data.

The Leontief or Input-Output model, and the associated matrices of economic activity and interconnectedness, provide a methodology for estimating the indirect and induced effects, or the knock-on effects on the economy associated with the direct impacts on the chemicals sector.

This model allows us to estimate the multipliers or factors that represent how one euro spent in one sector results in economic activity throughout the supply chain and/or other sectors and so on and so forth).

- Type I multipliers capture the direct and indirect effects only (that is, Type I multiplier – 1 would capture the indirect effects or the economic impacts throughout the supply chain).
- Type II multipliers also capture the induced effects, under the implicit assumption that final consumers do not change their final consumption patterns in response to changes in income (that is, Type II – 1 would capture the indirect and induced effects or the impact throughout the supply chain as well as the effects on the wider economy resulting from changes in compensation to employees).

For the production approach, the cumulative Type I and Type II multipliers have been assumed at around 1.8 and 2.2 respectively, based on evidence from Eurostat, national statistical databases from across Europe and expert judgment.

For the income approach, the cumulative Type I and Type II multipliers have been assumed at around 1.4 and 2.0 respectively, based on evidence from Eurostat, national statistical databases from across Europe and expert judgment.

## Annualisation of total impacts and costs

Where required, Equivalent Annual Costs or Impacts were calculated for the selected indicators.

First, the Net Present Value (NPV) of any impact or cost over the period 2021-2040 was estimated by summing the projected cost over the period and discounted at a real discount rate of 4%. This is in line with the pre-2021 Commission's Better Regulation Guidelines[89] and is not updated (as per the latest update of the guidelines, and particularly Tool #64 (discount factors)) for consistency with the Phase I Report.. The following equation was employed.

Equation 7-1 $NPV = \sum_{t=0}^{n} \frac{C_t}{(1+r)^t}$, where n refers to the time period from 2021-2040, Ct refers to the costs or impacts in time period t, and r refers to the real discount rate.

Secondly, the NPV of the cost or impact was multiplied by an annualization factor, pertaining to the period of policy impact, which is 2023-2040. This factor is given by the following equation.

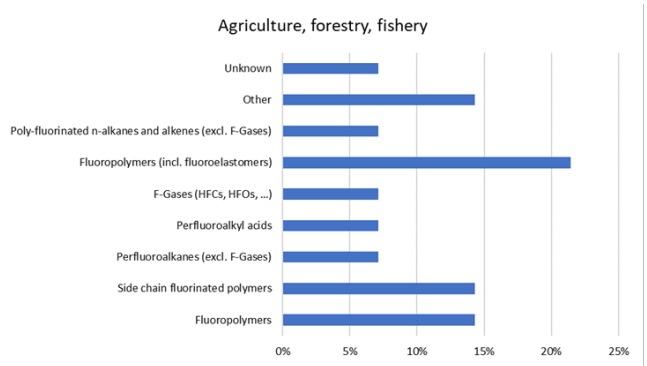
[89] European Commission (2008), *Tool #61. The Use Of Discount Rates*, Available from: https://ec.europa.eu/info/sites/info/files/file_import/better-regulation-toolbox-61_en_0.pdf

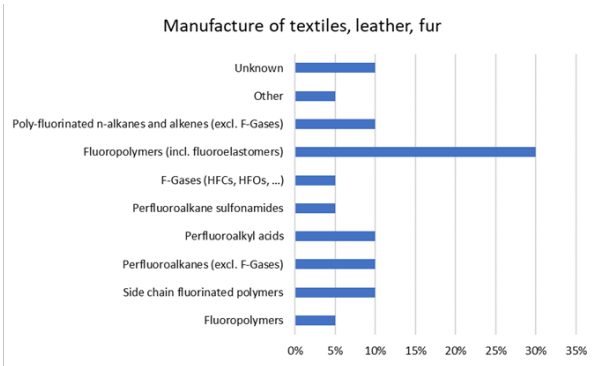
Please note that the suggestion to use a 3% real discount rate from the latest regulation guidelines are not employed for consistency with the Phase I report European Commission (2021). Tool #64. Discount factors. URL: https://ec.europa.eu/info/sites/default/files/br_toolbox_-_nov_2021_-_chapter_8.pdf

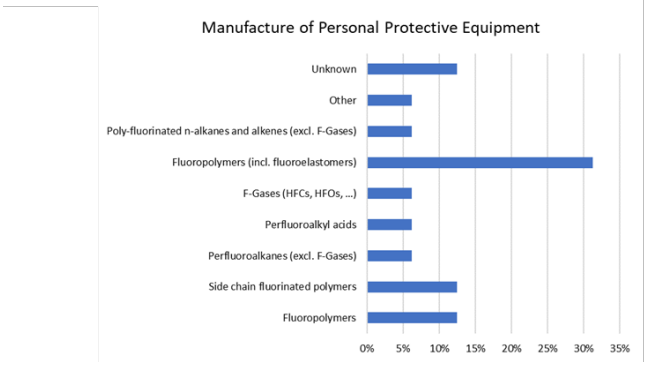
Equation 7-2 $AF = \mathrm{r}/[1-(1+r)^{-t}]$, where *r* refers to the real discount rate and *n* refers to the number of periods. Note that this formula and approach were adapted to account for the timetable of policy implementation. No impacts are expected before 2023.

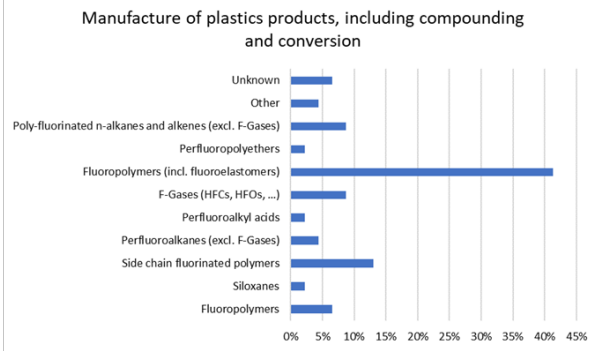
# Appendix 3 PFAS use across sectors

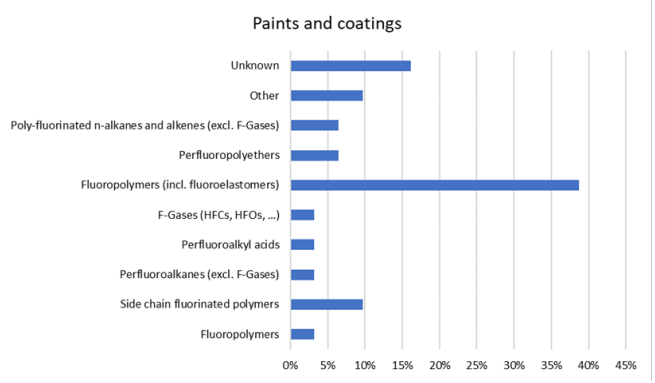
This Appendix presents an overview of the types of PFAS that are being used in the sectors covered by this Study. The data presented is based on responses to the consultation of manufacturers/ importers and downstream users of PFAS. The percentages reflect the number of respondents per sector that use PFAS in certain forms e.g. fluoropolymers. There are varying numbers of respondents per sector and the percentages presented are based on the sample for the sector and not the entire sample. This is supplementary information to support that given in Section 3.1.

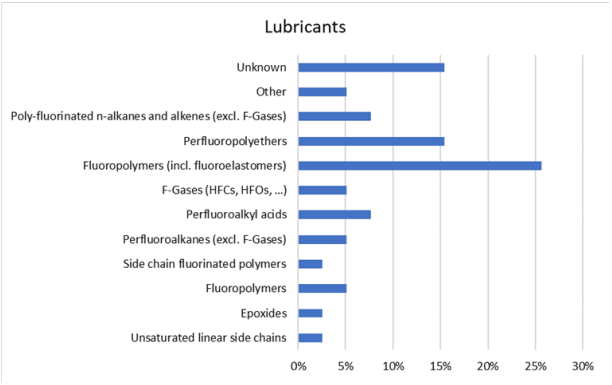


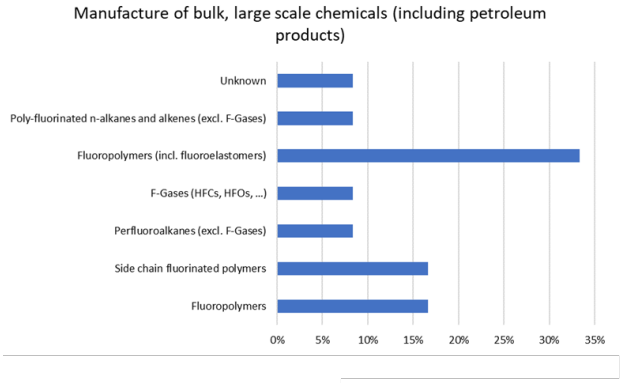



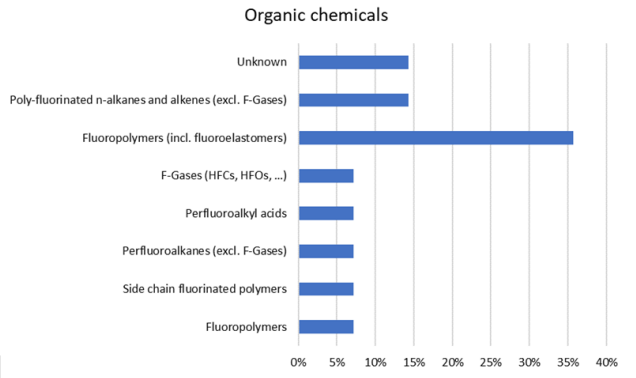



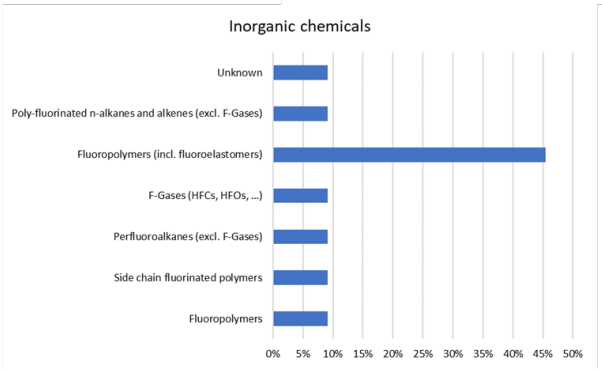



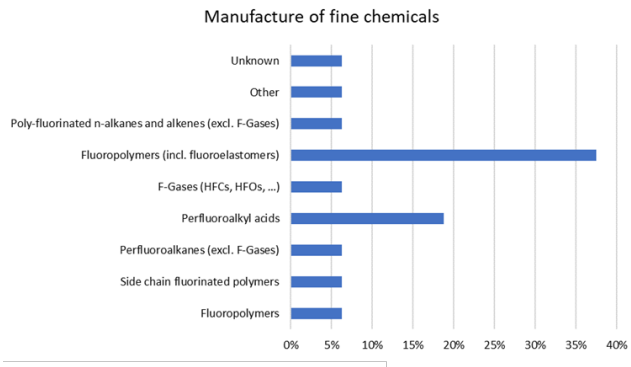



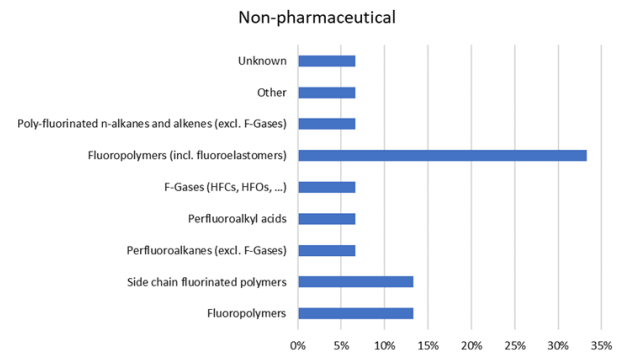



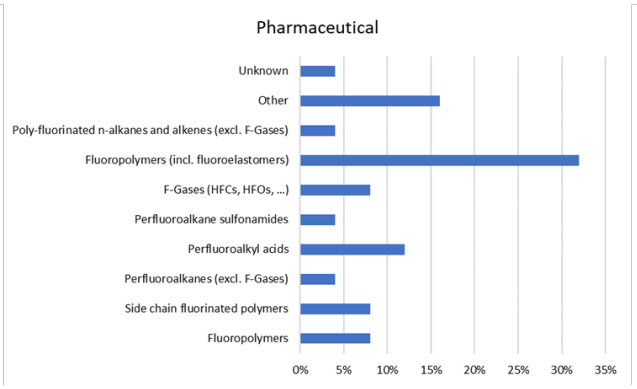

Manufacture of bulk, large scale chemicals (including petroleum products)
Unknown
Poly-fluorinated n-alkanes and alkenes (excl. F-Gases)
Fluoropolymers (incl. fluoroelastomers)
F-Gases (HFCs, HFOs, ...)
Perfluoroalkanes (excl. F-Gases)
Side chain fluorinated polymers
Fluoropolymers
0% 5% 10% 15% 20% 25% 30% 35%

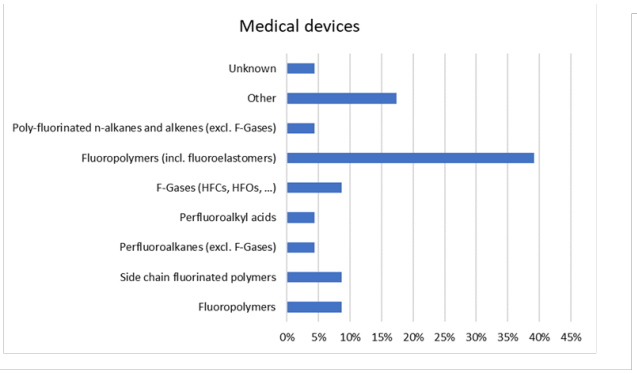

Organic chemicals
Unknown
Poly-fluorinated n-alkanes and alkenes (excl. F-Gases)
Fluoropolymers (incl. fluoroelastomers)
F-Gases (HFCs, HFOs, ...)
Perfluoroalkyl acids
Perfluoroalkanes (excl. F-Gases)
Side chain fluorinated polymers
Fluoropolymers
0% 5% 10% 15% 20% 25% 30% 35% 40%

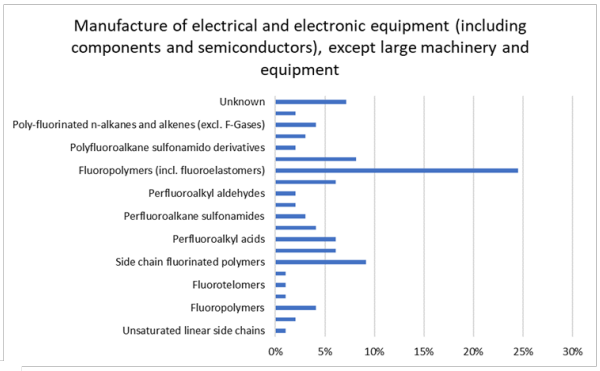

Inorganic chemicals
Unknown
Poly-fluorinated n-alkanes and alkenes (excl. F-Gases)
Fluoropolymers (incl. fluoroelastomers)
F-Gases (HFCs, HFOs, ...)
Perfluoroalkanes (excl. F-Gases)
Side chain fluorinated polymers
Fluoropolymers
0% 5% 10% 15% 20% 25% 30% 35% 40% 45% 50%

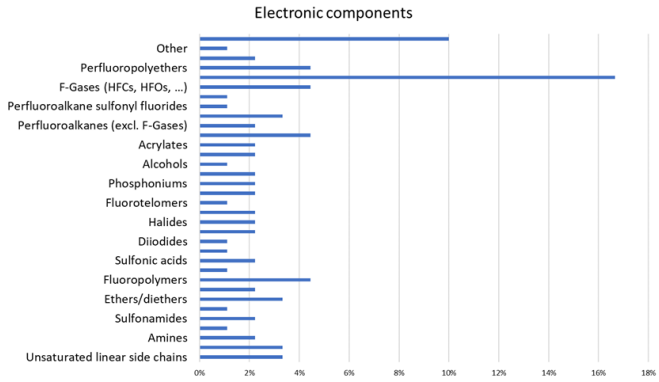

Manufacture of fine chemicals
Unknown
Other
Poly-fluorinated n-alkanes and alkenes (excl. F-Gases)
Fluoropolymers (incl. fluoroelastomers)
F-Gases (HFCs, HFOs, ...)
Perfluoroalkyl acids
Perfluoroalkanes (excl. F-Gases)
Side chain fluorinated polymers
Fluoropolymers
0% 5% 10% 15% 20% 25% 30% 35% 40%

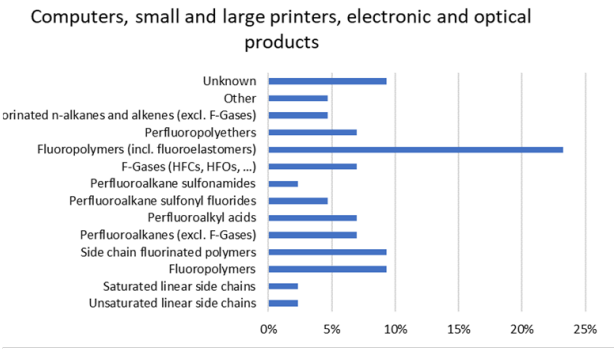

Non-pharmaceutical
Unknown
Other
Poly-fluorinated n-alkanes and alkenes (excl. F-Gases)
Fluoropolymers (incl. fluoroelastomers)
F-Gases (HFCs, HFOs, ...)
Perfluoroalkyl acids
Perfluoroalkanes (excl. F-Gases)
Side chain fluorinated polymers
Fluoropolymers
0% 5% 10% 15% 20% 25% 30% 35%

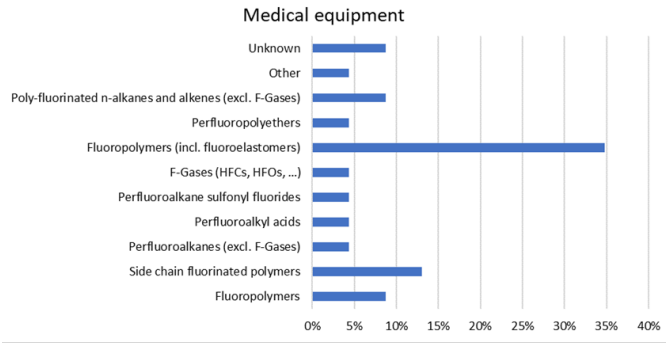

Pharmaceutical
Unknown
Other
Poly-fluorinated n-alkanes and alkenes (excl. F-Gases)
Fluoropolymers (incl. fluoroelastomers)
F-Gases (HFCs, HFOs, ...)
Perfluoroalkane sulfonamides
Perfluoroalkyl acids
Perfluoroalkanes (excl. F-Gases)
Side chain fluorinated polymers
Fluoropolymers
0% 5% 10% 15% 20% 25% 30% 35%


Medical devices
Unknown
Other
Poly-fluorinated n-alkanes and alkenes (excl. F-Gases)
Fluoropolymers (incl. fluoroelastomers)
F-Gases (HFCs, HFOs, ...)
Perfluoroalkyl acids
Perfluoroalkanes (excl. F-Gases)
Side chain fluorinated polymers
Fluoropolymers
0% 5% 10% 15% 20% 25% 30% 35% 40% 45%


Manufacture of electrical and electronic equipment (including components and semiconductors), except large machinery and equipment
Unknown
Poly-fluorinated n-alkanes and alkenes (excl. F-Gases)
Polyfluoroalkane sulfonamido derivatives
Fluoropolymers (incl. fluoroelastomers)
Perfluoroalkyl aldehydes
Perfluoroalkane sulfonamides
Perfluoroalkyl acids
Side chain fluorinated polymers
Fluorotelomers
Fluoropolymers
Unsaturated linear side chains
0% 5% 10% 15% 20% 25% 30%


Electronic components
Other
Perfluoropolyethers
F-Gases (HFCs, HFOs, ...)
Perfluoroalkane sulfonyl fluorides
Perfluoroalkanes (excl. F-Gases)
Acrylates
Alcohols
Phosphoniums
Fluorotelomers
Halides
Diiodides
Sulfonic acids
Fluoropolymers
Ethers/diethers
Sulfonamides
Amines
Unsaturated linear side chains
0% 2% 4% 6% 8% 10% 12% 14% 16% 18%


Computers, small and large printers, electronic and optical products
Unknown
Other
orinated n-alkanes and alkenes (excl. F-Gases)
Perfluoropolyethers
Fluoropolymers (incl. fluoroelastomers)
F-Gases (HFCs, HFOs, ...)
Perfluoroalkane sulfonamides
Perfluoroalkane sulfonyl fluorides
Perfluoroalkyl acids
Perfluoroalkanes (excl. F-Gases)
Side chain fluorinated polymers
Fluoropolymers
Saturated linear side chains
Unsaturated linear side chains
0% 5% 10% 15% 20% 25%


Medical equipment
Unknown
Other
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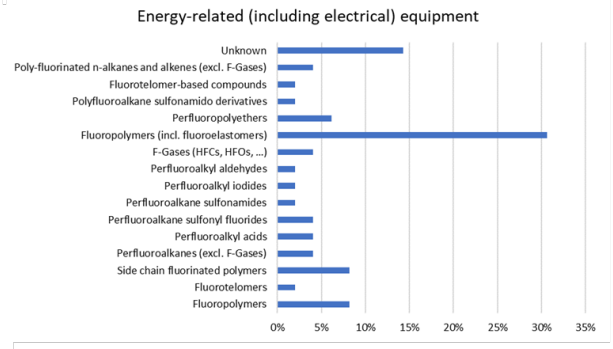
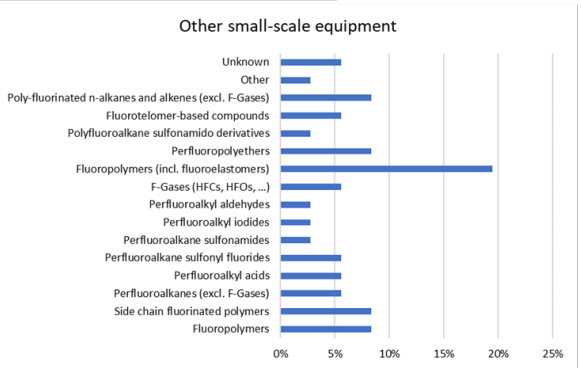
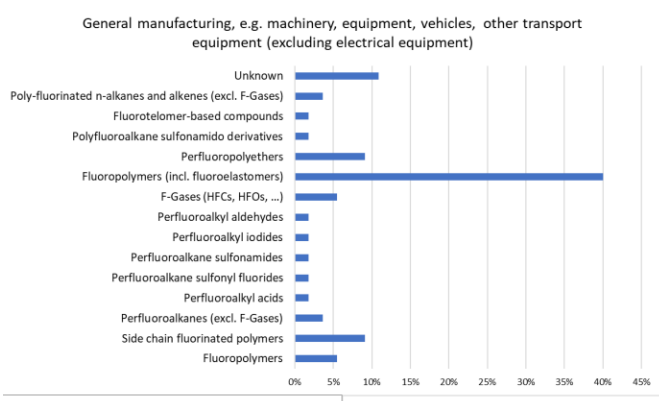
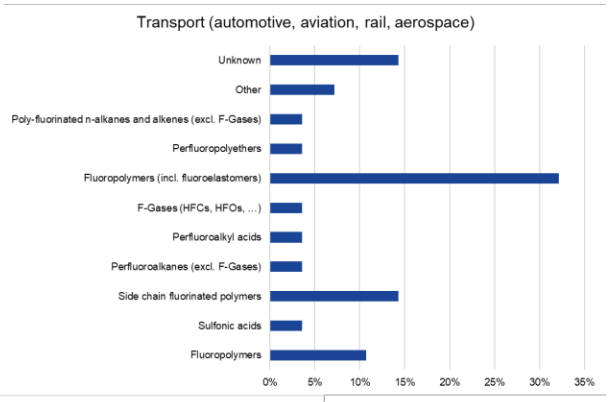
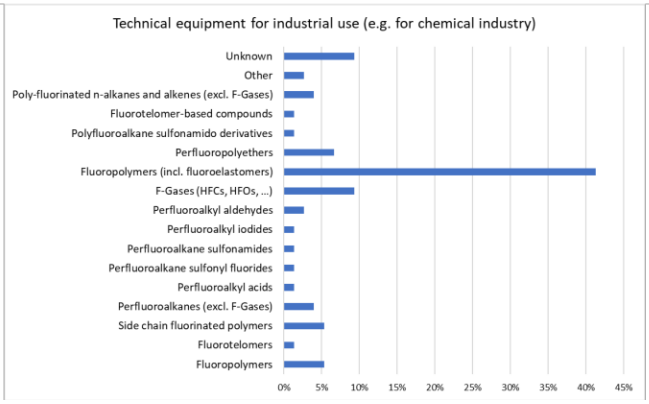
Perfluoropolyethers
Fluoropolymers (incl. fluoroelastomers)
F-Gases (HFCs, HFOs, ...)
Perfluoroalkane sulfonyl fluorides
Perfluoroalkyl acids
Perfluoroalkanes (excl. F-Gases)
Side chain fluorinated polymers
Fluoropolymers
0% 5% 10% 15% 20% 25% 30% 35% 40%

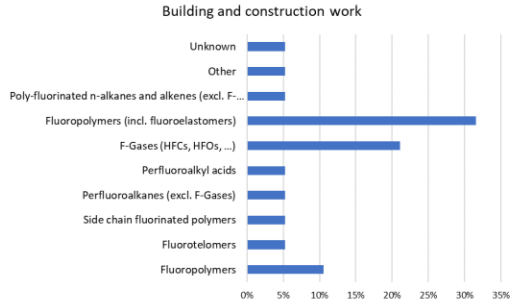

Energy-related (including electrical) equipment
Unknown
Poly-fluorinated n-alkanes and alkenes (excl. F-Gases)
Fluorotelomer-based compounds
Polyfluoroalkane sulfonamido derivatives
Perfluoropolyethers
Fluoropolymers (incl. fluoroelastomers)
F-Gases (HFCs, HFOs, ...)
Perfluoroalkyl aldehydes
Perfluoroalkyl iodides
Perfluoroalkane sulfonamides
Perfluoroalkane sulfonyl fluorides
Perfluoroalkyl acids
Perfluoroalkanes (excl. F-Gases)
Side chain fluorinated polymers
Fluorotelomers
Fluoropolymers
0% 5% 10% 15% 20% 25% 30% 35%

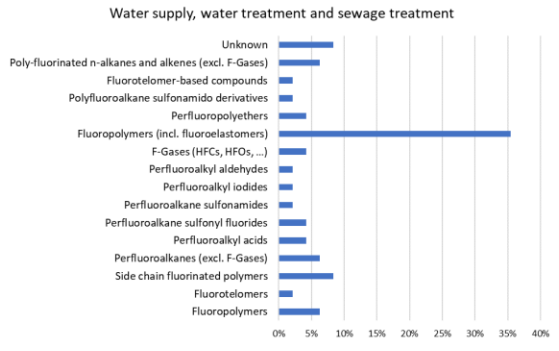

Other small-scale equipment
Unknown
Other
Poly-fluorinated n-alkanes and alkenes (excl. F-Gases)
Fluorotelomer-based compounds
Polyfluoroalkane sulfonamido derivatives
Perfluoropolyethers
Fluoropolymers (incl. fluoroelastomers)
F-Gases (HFCs, HFOs, ...)
Perfluoroalkyl aldehydes
Perfluoroalkyl iodides
Perfluoroalkane sulfonamides
Perfluoroalkane sulfonyl fluorides
Perfluoroalkyl acids
Perfluoroalkanes (excl. F-Gases)
Side chain fluorinated polymers
Fluoropolymers
0% 5% 10% 15% 20% 25%

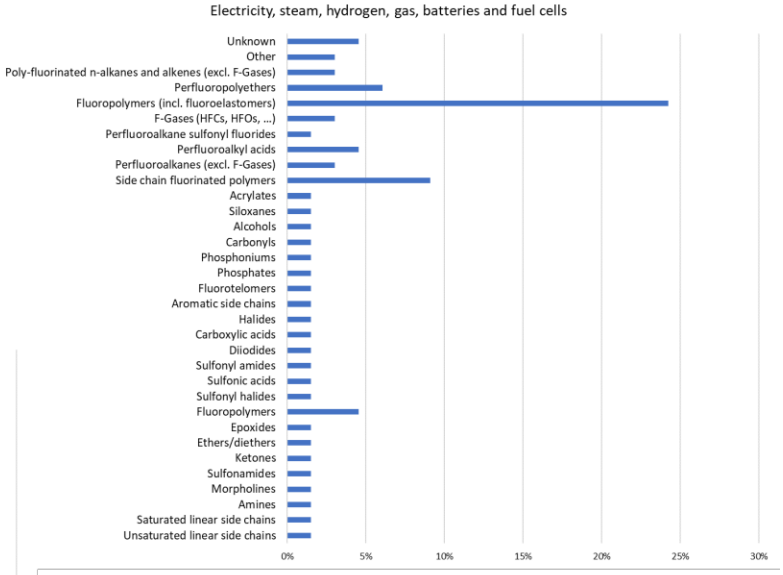

General manufacturing, e.g. machinery, equipment, vehicles, other transport equipment (excluding electrical equipment)
Unknown
Poly-fluorinated n-alkanes and alkenes (excl. F-Gases)
Fluorotelomer-based compounds
Polyfluoroalkane sulfonamido derivatives
Perfluoropolyethers
Fluoropolymers (incl. fluoroelastomers)
F-Gases (HFCs, HFOs, ...)
Perfluoroalkyl aldehydes
Perfluoroalkyl iodides
Perfluoroalkane sulfonamides
Perfluoroalkane sulfonyl fluorides
Perfluoroalkyl acids
Perfluoroalkanes (excl. F-Gases)
Side chain fluorinated polymers
Fluoropolymers
0% 5% 10% 15% 20% 25% 30% 35% 40% 45%

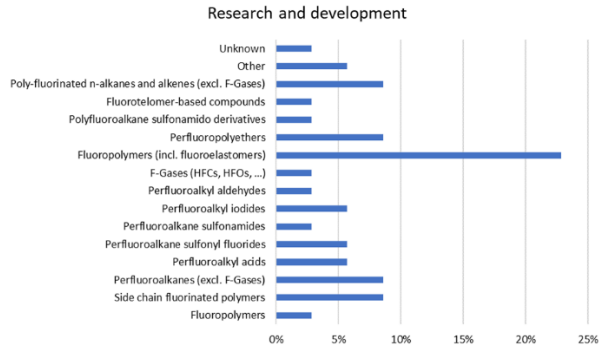

Transport (automotive, aviation, rail, aerospace)
Unknown
Other
Poly-fluorinated n-alkanes and alkenes (excl. F-Gases)
Perfluoropolyethers
Fluoropolymers (incl. fluoroelastomers)
F-Gases (HFCs, HFOs, ...)
Perfluoroalkyl acids
Perfluoroalkanes (excl. F-Gases)
Side chain fluorinated polymers
Sulfonic acids
Fluoropolymers
0% 5% 10% 15% 20% 25% 30% 35%

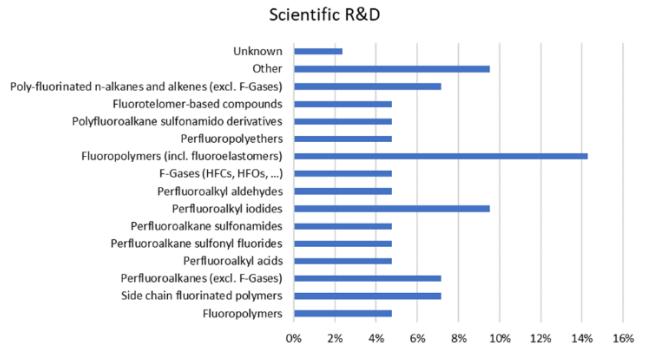

Technical equipment for industrial use (e.g. for chemical industry)
Unknown
Other
Poly-fluorinated n-alkanes and alkenes (excl. F-Gases)
Fluorotelomer-based compounds
Polyfluoroalkane sulfonamido derivatives
Perfluoropolyethers
Fluoropolymers (incl. fluoroelastomers)
F-Gases (HFCs, HFOs, ...)
Perfluoroalkyl aldehydes
Perfluoroalkyl iodides
Perfluoroalkane sulfonamides
Perfluoroalkane sulfonyl fluorides
Perfluoroalkyl acids
Perfluoroalkanes (excl. F-Gases)
Side chain fluorinated polymers
Fluorotelomers
Fluoropolymers
0% 5% 10% 15% 20% 25% 30% 35% 40% 45%

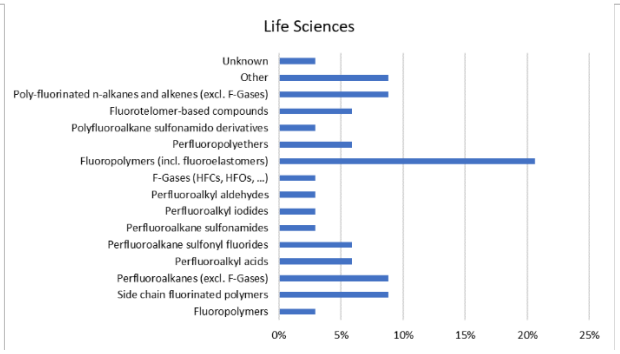

Building and construction work
Unknown
Other
Poly-fluorinated n-alkanes and alkenes (excl. F-...
Fluoropolymers (incl. fluoroelastomers)
F-Gases (HFCs, HFOs, ...)
Perfluoroalkyl acids
Perfluoroalkanes (excl. F-Gases)
Side chain fluorinated polymers
Fluorotelomers
Fluoropolymers
0% 5% 10% 15% 20% 25% 30% 35%


Water supply, water treatment and sewage treatment
Unknown
Poly-fluorinated n-alkanes and alkenes (excl. F-Gases)
Fluorotelomer-based compounds
Polyfluoroalkane sulfonamido derivatives
Perfluoropolyethers
Fluoropolymers (incl. fluoroelastomers)
F-Gases (HFCs, HFOs, ...)
Perfluoroalkyl aldehydes
Perfluoroalkyl iodides
Perfluoroalkane sulfonamides
Perfluoroalkane sulfonyl fluorides
Perfluoroalkyl acids
Perfluoroalkanes (excl. F-Gases)
Side chain fluorinated polymers
Fluorotelomers
Fluoropolymers
0% 5% 10% 15% 20% 25% 30% 35% 40%

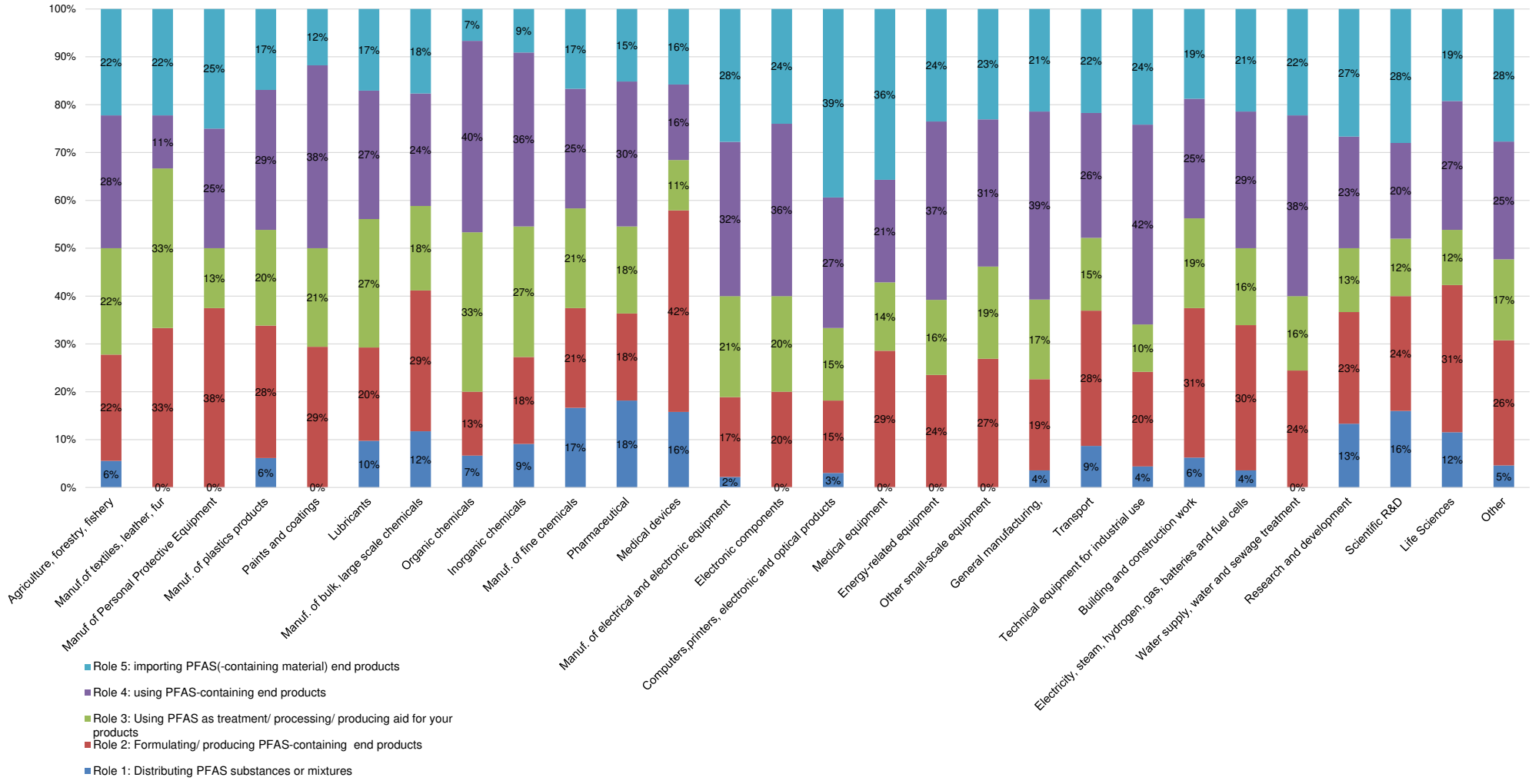

Electricity, steam, hydrogen, gas, batteries and fuel cells
Unknown
Other
Poly-fluorinated n-alkanes and alkenes (excl. F-Gases)
Perfluoropolyethers
Fluoropolymers (incl. fluoroelastomers)
F-Gases (HFCs, HFOs, ...)
Perfluoroalkane sulfonyl fluorides
Perfluoroalkyl acids
Perfluoroalkanes (excl. F-Gases)
Side chain fluorinated polymers
Acrylates
Siloxanes
Alcohols
Carbonyls
Phosphoniums
Phosphates
Fluorotelomers
Aromatic side chains
Halides
Carboxylic acids
Diiodides
Sulfonyl amides
Sulfonic acids
Sulfonyl halides
Fluoropolymers
Epoxides
Ethers/diethers
Ketones
Sulfonamides
Morpholines
Amines
Saturated linear side chains
Unsaturated linear side chains
0% 5% 10% 15% 20% 25% 30%


Research and development
Unknown
Other
Poly-fluorinated n-alkanes and alkenes (excl. F-Gases)
Fluorotelomer-based compounds
Polyfluoroalkane sulfonamido derivatives
Perfluoropolyethers
Fluoropolymers (incl. fluoroelastomers)
F-Gases (HFCs, HFOs, ...)
Perfluoroalkyl aldehydes
Perfluoroalkyl iodides
Perfluoroalkane sulfonamides
Perfluoroalkane sulfonyl fluorides
Perfluoroalkyl acids
Perfluoroalkanes (excl. F-Gases)
Side chain fluorinated polymers
Fluoropolymers
0%
5%
10%
15%
20%
25%


Scientific R&D
Unknown
Other
Poly-fluorinated n-alkanes and alkenes (excl. F-Gases)
Fluorotelomer-based compounds
Polyfluoroalkane sulfonamido derivatives
Perfluoropolyethers
Fluoropolymers (incl. fluoroelastomers)
F-Gases (HFCs, HFOs, ...)
Perfluoroalkyl aldehydes
Perfluoroalkyl iodides
Perfluoroalkane sulfonamides
Perfluoroalkane sulfonyl fluorides
Perfluoroalkyl acids
Perfluoroalkanes (excl. F-Gases)
Side chain fluorinated polymers
Fluoropolymers
0%
2%
4%
6%
8%
10%
12%
14%
16%


Life Sciences
Unknown
Other
Poly-fluorinated n-alkanes and alkenes (excl. F-Gases)
Fluorotelomer-based compounds
Polyfluoroalkane sulfonamido derivatives
Perfluoropolyethers
Fluoropolymers (incl. fluoroelastomers)
F-Gases (HFCs, HFOs, ...)
Perfluoroalkyl aldehydes
Perfluoroalkyl iodides
Perfluoroalkane sulfonamides
Perfluoroalkane sulfonyl fluorides
Perfluoroalkyl acids
Perfluoroalkanes (excl. F-Gases)
Side chain fluorinated polymers
Fluoropolymers
0%
5%
10%
15%
20%
25%

## Figure 7-1 Roles of operations related to PFAS by application



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