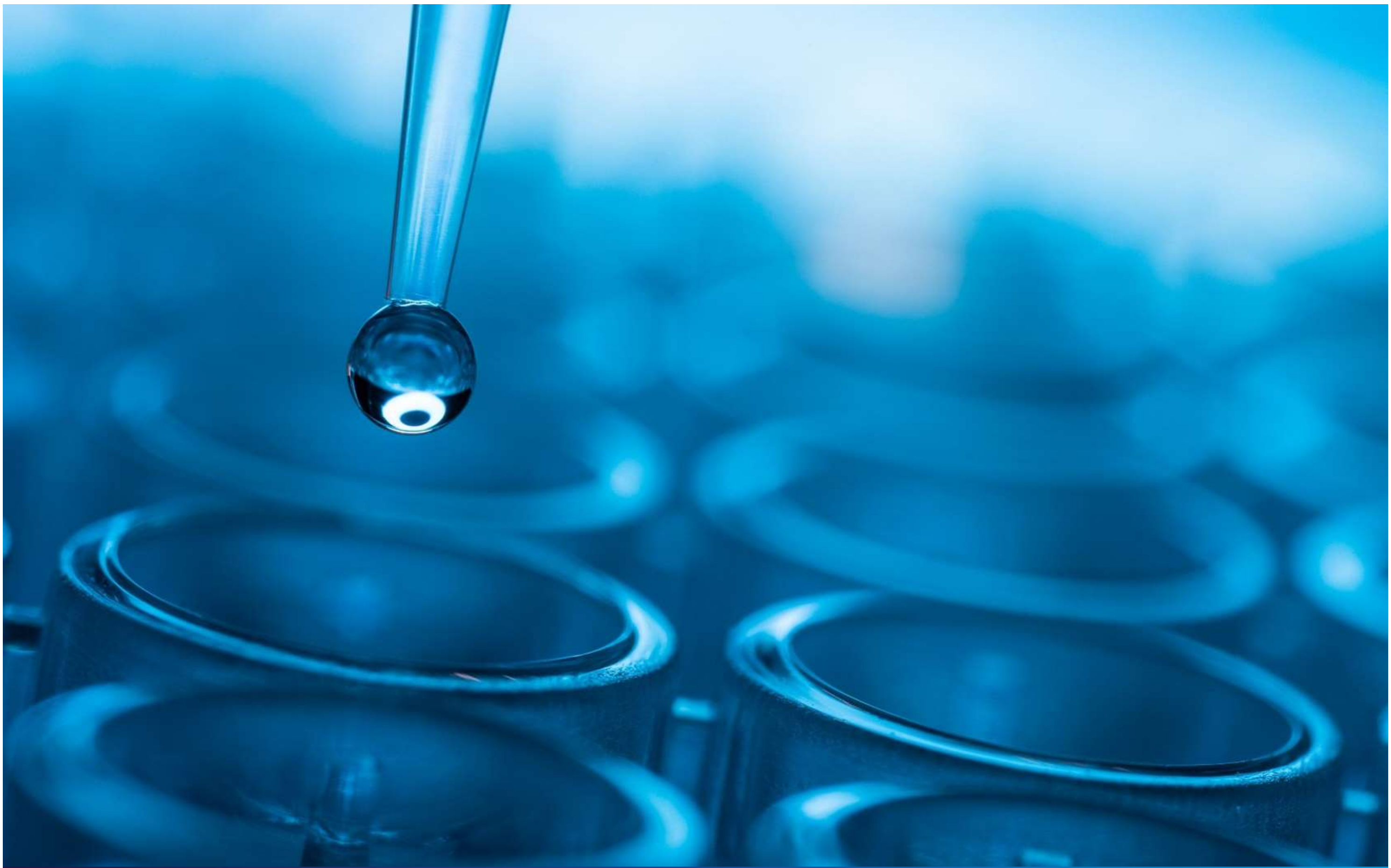

SOCIO-ECONOMIC ANALYSIS FOR A REACH RESTRICTION PROPOSAL ON 1,4-DIOXANE AS AN IMPURITY

Final Report for: European Committee of Organic Surfactants and their intermediates (CESIO)

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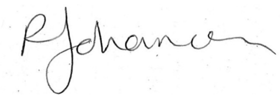

Date:
29 October 2024

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EXECUTIVE SUMMARY

This Study has been commissioned by the European Committee of Organic Surfactants and their Intermediates (CESIO) **to provide an independent Socio-Economic Analysis (SEA) for the potential REACH restriction of 1,4-dioxane as an impurity in surfactants**. This analysis focuses on manufacturers and importers of Ethoxylated (EO) surfactants and five selected Downstream User sectors, which represent more than 80% of the surfactant consumption in Western Europe.

Background

The German REACH competent authority have expressed an intention for a potential REACH restriction of the manufacture, placing on the market and use of 1,4-dioxane in surfactants. This is due to concerns on the persistence and mobility of 1,4-dioxane in water resources and its classification as carcinogenic 1B for human health. The manufacturing of surfactants has been identified as a source of 1,4-dioxane emissions to the environment[1].

The call for evidence published on the 19th of April 2023 by the German REACH competent authority covered the restriction of the manufacture and use of surfactants which contain more than 1 mg of 1,4-dioxane in 1 kg of surfactant active matter (1 ppm of 1,4-dioxane). A consultation on this call for evidence was held in 2023[2]. However, the expected submission of the proposed restriction has since been delayed until October 2025.

Scope of the Assessment

The scope of this assessment is limited to EO-based surfactants that contain 1,4-dioxane as an impurity. This study investigates the potential economic and environmental impacts associated with the manufacture, placing on the market and use of EO-based surfactants containing 1,4-dioxane as an impurity. The downstream user sectors in scope of this assessment are cosmetics and personal care products; paints, coatings, adhesives, elastomers, and printing inks; detergents and cleaning products; agrochemical products and applications; and chemical products for the textiles and leather sector. Other downstream sectors, such as lubricants, metal working, oilfield and mining, construction products, and pharmaceutical products, use these surfactants as well but could not be included in the Study due to their limited participation in the targeted stakeholder consultation. The geographical scope of the analysis is the EU-27.

The Baseline and Proposed Restriction Scenarios in scope

A baseline ('do nothing' scenario) and two restriction scenarios have been assessed in this study. These restriction scenarios were derived in discussions with CESIO and are as follows:

- Restriction Scenario (RS) 1: Restriction of manufacturing and/or placing on the EU-27 market, surfactants with 1 ppm or more (≥ 1 ppm) of 1,4-dioxane as an impurity in active matter.
- RS 2: Restriction of manufacturing and/or placing on the EU-27 market, surfactants with 10 ppm or more (≥ 10 ppm) of 1,4-dioxane as an impurity in active matter[3].

Method overview

The methodology used in this study consists of several steps, in line with ECHA's SEA guidelines, and are summarised as follows.

- **Define and characterise the baseline scenario**, against which the impacts of the two restriction scenarios will be assessed for 2026-2040. This includes employing statistical techniques and publicly available sources (such as Eurostat's Structural Business Statistics) combined with data reported by industry stakeholders.
- **Consult industry stakeholders and gather evidence of the baseline and the potential impacts**. This involved a literature review, consultation (survey) of industry stakeholders and follow up consultation activities with manufacturers and importers and downstream user sectors.

[1] ECHA (2023). Registry of restriction intentions until outcome – 1,4-dioxane. Available at: https://echa.europa.eu/registry-of-restriction-intentions/-/dislist/details/0b0236e18609e1d9

[2] ECHA (2023). Call for Evidence and Information on 1,4-dioxane as well as Substances and Mixtures Containing 1,4-dioxane as a Constituent or an Impurity. Available at: https://echa.europa.eu/documents/10162/5d05d8e1-27bb-74c5-b102-d5b903aa7e13

[3] This restriction scenario was added, following a suggestion from BAuA dated 26th September 2023.

- **Assess of the economic and environmental impacts of the restriction scenarios,** over the period 2026-2040 quantitively, where possible (some economic impacts), or otherwise qualitatively (environmental impacts) using a Multi-Criteria Analysis (MCA) method.
- **Compare the impacts of the restriction scenarios.** The emission abatement costs or 'cost-effectiveness' of the two restriction scenarios were estimated and compared against recent REACH restrictions. Additionally, an MCA method has been employed for comparing the direction (positive or negative) and magnitude (weak to strong, limited or unclear) of the impacts.

The quantitative and qualitative assessment methods employed to characterise and compare the impacts of the scenarios over the period of 2026-2040 are further described below.

- The impacts of the restriction scenarios against the baseline have been quantified, where evidence was available. Quantitative analysis has been performed to estimate: i) the level of economic activity in the EU-27 that would require some type of transformation (e.g., substitution and/or product adjustment) across the sectors in scope, and the compliance (capital and operating) costs that would be incurred to achieve this; and ii) the emissions of 1,4-dioxane into the environment, under each restriction scenario against the baseline. The emissions have been calculated for manufacturers and the downstream user sectors using tonnages, average ppm concentrations and affected portfolios which is detailed in Appendix 1.
- The impacts of the restriction scenarios against the baseline have been qualitatively assessed (including the direction and relative magnitude), where quantitative evidence was not available. Qualitative methods also allow for bringing the overall assessment together to develop conclusions. For example, the evidence available was considered to establish a relative magnitude and direction of impact for the EU industry's competitiveness in a global context, considering the effects on costs of doing business and trade, drawing on the Commission's Better Regulation[4] and ECHA's guidelines. A qualitative analysis has also been conducted to conclude on the effects of the restriction scenarios against the baseline on the use of resources (e.g., energy) and waste production and treatment.

The outputs of the assessment were used to establish comparable and evidence-based 'scores', following a scale of -5 to +5 to reflect the direction (positive or negative) and the magnitude of impact (weakly: 1 to strongly: 5, limited: 0 or unclear impacts: N/A), which are illustrated in the Table below. This methodology, based on MCA principles, required an iterative and multidisciplinary approach that is detailed in Appendix 1.

Table 0-1 Scoring and colour-coding framework used for the overall, qualitative assessment

Strongly negative	Negative	Weakly negative	No or limited impact	Weakly positive	Positive	Strongly positive	Unclear
-5	-3	-1	0	+1	+3	+5	N/A

Drawing on the qualitative assessment of the scale and direction of the most significant impacts that the restriction scenarios might have on the affected stakeholders, benefit:cost ratios have also been highlighted as a way to explore the balance of costs and benefits associated with the restriction proposals. A benefit:cost ratio that is lower than 1 suggests that benefits are likely to be lower than costs.

Analysis of economic and environmental impacts

Economic impacts

- The restriction scenarios under consideration could pose significant challenges for manufacturers and importers of surfactants in the EU-27. For RS1, an average of 70% (50%-100%)[5] of the sales turnover could be potentially affected, including the production of some key surfactant classes such as alkyl ether sulfates, and 40% (15%-50%) of sales could be potentially affected under RS2. Downstream

[4] European Commission (2024) Better regulation: guidelines and toolbox. Available from: https://commission.europa.eu/law/law-making-process/planning-and-proposing-law/better-regulation/better-regulation-guidelines-and-toolbox_en

[5] Please note that figures in brackets represent possible but unlikely lower and upper bounds and capture the potential uncertainty in the available evidence.

user sectors who rely on surfactants in their products will also be impacted by the restriction scenarios, with on average 65% (45-90%) of all 'downstream user' sales in the EU-27 being potentially affected under RS1 and 40% (10-65%) under RS2..

- Alternatives and substitutes exist, particularly for RS2 and to a lower extent, RS1, but the extent and scale of substitution is uncertain. The level of 1.4-dioxane as an impurity can be reduced by removal or 'stripping' technologies. However, these also have cost implications (i.e. CAPEX and energy requirements). Under RS1, manufacturers and importers could adjust and/or substitute with alternatives 25% (0%-60%) of the affected portfolio of surfactants and 70% (50%-95%) for RS2. On average, 65% (30-100%) of the baseline affected production activities of the 'downstream user' sectors in the EU-27 could be potentially adjusted and/or substituted with similarly performing alternatives under RS1 and 90% (65-100%) under RS2.
- Under both restriction scenarios, upstream and downstream companies will face significant costs of transformation or adjustment. The adjustment costs for manufacturers and importers of surfactants for both restriction scenarios are likely to be large, surpassing €4 billion in Net Present Value (NPV) under both restriction scenarios, which is equivalent to a cost of over €300 million each year over 2026-2040. For downstream users, these costs could surpass €8 billion in Net Present Value, equivalent to around €700 million each year over 2026-2040.
- The cost of doing business in the EU-27 surfactant value chain could increase, particularly for manufacturers and, to a lesser degree, importers who would not face the necessary investment in wastewater treatment. There could also be significant negative wider economic impacts on the EU society for both restriction scenarios, particularly for employment and consumer product accessibility and availability.
- **Thus overall, the EU's economy could be negatively impacted by the restriction scenarios. The total impacts on Gross Value Added (GVA) could be lower by an estimated €45 billion a year under RS1 and €5 billion a year under RS2.**

Environmental impacts

- The environmental concerns of 1,4-dioxane are related to its persistence and mobility in water sources. It is estimated that current emissions of 1,4-dioxane from surfactants under the baseline are between 8-35 tonnes per annum (tpa) for manufacturers in the EU-27 and 5-25 tpa (indirect emissions) for the downstream user sectors in scope.
- Under both restriction scenarios, there would be a reduction in the emissions in 1,4-dioxane to water from surfactants. It is estimated that there could be a reduction of emissions by 90%-100% for manufacturers under RS1 and 35%-80% under RS2. For the downstream user sectors, it is estimated that there could be a reduction in emissions by 80%-98% under RS1 and 50%-80% under RS2.
- These reductions in emissions could have a positive impact on the quality of natural resources (water) for both restriction scenarios. There could also be a positive impact on emission reduction from the increased use of 1,4-dioxane stripping by manufacturers, if the wastewater were subsequently treated to remove 1,4-dioxane.
- On the other hand, there could be negative impacts on the use of resources (energy). Under RS1 and to a lesser degree RS2, manufacturers may use 1,4-dioxane stripping technologies to reduce the 1,4-dioxane in surfactant followed by treatment of the wastewater containing the stripped 1,4-dioxane. This is an energy-intensive process which would result in increased energy consumption with a greater degree of impact assumed under RS1.
- **It is most likely that there will be net positive impacts on the environment that could result from the adoption of either of the restriction scenarios.** Please note that this is based on the presumption that the wastewater from stripping or other measures to reduce 1,4-dioxane in surfactants are subsequently treated, although it is acknowledged that this is not currently a requirement in all Member States.

The Comparison of the Restriction Scenarios

Finally, the outputs of the impacts of the restriction scenarios were brought together into comparable ratings across the broad economic and environmental impacts categories and overall costs and benefits for the two restriction scenarios for analysis. An estimation of the cost-effectiveness was developed to produce additional insights and to facilitate comparability scoring.

Cost-effectiveness

The chemical emissions' abatement costs of the restriction scenarios were estimated using cost-effectiveness indicators that draw on methodologies developed by ECHA and the Committee for Socio-Economic Analysis (SEAC).

For this comparison, we have developed a statistic based on the NPV of adjustment (or compliance) costs previously estimated, divided by the total 1,4-dioxane emission reductions estimated for the period of analysis. Thus, the table below presents the output of this analysis, which highlights that the reductions in emissions could cost the EU around 117,000 €/kg for RS1 and 50,000 €/kg for RS2. These estimates can be compared, at a high-level against the costs per kilogram of persistent chemical release reductions from recent REACH restrictions. These show that the estimated abatement costs under these restriction scenarios are many times higher than those from recent REACH restrictions (e.g., 30-100 times higher than that for PFOA). **Based on this, it is considered that the restriction scenarios under consideration are unlikely to be a cost-effective way for reducing overall 1,4-dioxane emissions**.

Table 0-2 Cost-effectiveness of RS1 and RS2 and recent REACH restrictions on Chemicals.

Chemical	€/kg of emissions reductions
1,4-dioxane- RS1	117,000 €/kg (46,000 – 158,000 €/kg)
1,4-dioxane- RS2	50,000 €/kg (33,000 – 80,000 €/kg)
Previous case for comparison	
Lead in shot in wetlands	9 €/kg
Lead in PVC (under decision-making)	308 €/kg
D4, D5 in wash-off cosmetics	415 €/kg
DecaBDE	464 €/kg
Phenylmercury compounds	649 €/kg
PFOA-related substances	734 €/kg
PFOA	1,649 €/kg

Balance of economic and environmental impacts, costs and benefits

In addition, these and other outputs of the assessment were brought together across the broad economic and environmental impact categories and summarised in the Table below.

Table 0-3 Overview of the economic and environmental impacts for each restriction scenario.

Restriction Scenario	Economic impacts	Environmental impacts
Restriction Scenario 1 (against baseline)	-3.6	+0.5

Restriction Scenario	Economic impacts	Environmental impacts
Restriction Scenario 2 (against baseline)	-1.4	+0.2

Source: Ricardo analysis based on the evidence presented in this Study.

The assessment concludes the restriction scenarios are likely to have negative economic impacts (-3.6 and -1.4 for RS1 and RS2 respectively) and limited, positive environmental impacts (+0.5 and +0.2 for RS1 and RS2 respectively). The scale of the potential, positive environmental impacts is concluded to be much lower than that of negative economic impacts. Thus, **the restriction scenarios appear to have a negative balance of economic and environmental impacts**.

Finally, the balance of costs and benefits to EU society provides additional insights into the merits of each restriction scenario and how likely they are to contribute to addressing the problems outlined earlier, as well as meeting the EU's general objective in a cost-effective way.

Table 0-4 Economic and environmental costs and benefits of the restriction scenarios against the baseline

Restriction Scenario	Costs	Benefits	Benefit: Cost Ratio
Restriction Scenario 1 (against baseline)	-5.0	+1.8	0.4
Restriction Scenario 2 (against baseline)	-2.0	+0.9	0.4

Source: Ricardo analysis based on the evidence presented in this Study.

The scale of the potential benefits that might result from the restriction scenarios has been assessed to be lower than that of potential costs. The assessment has highlighted a range of costs that could be incurred across the economic and environmental dimensions. In addition, some potential benefits have been identified, such as for the potential for innovation and the quality of natural resources (water). **These benefits are considered to be of insufficient scale, which is represented by a benefit-to-cost ratio (BCR) lower than 1 for both of the restriction scenarios.**

Please refer to the method overview of this summary, and Section 2 and Appendix 1 of this Study for more details on the methodology employed.

Conclusions

The outputs of this assessment and the comparison of impacts across the restriction scenarios suggest that:

- Under both restriction scenarios, the abatement costs for reducing the emissions of 1,4-dioxane in surfactants are more than 30 times larger than those of PFOA, which are used as a reference of the highest 'willingness to pay' there is, in the EU, to reduce the emissions of persistent substances to the environment.
- Costs that could be incurred from the adoption of either of the restriction scenarios include negative impacts in economic and environmental categories. Benefits that could occur under either of the restriction scenarios include potentially positive impacts on innovation and research and water quality and resources.
- Under both restriction scenarios, the scale of economic and environmental benefits has been assessed to be lower than the costs. This has also been highlighted by estimates of the potential benefit: cost ratio, below 1 for both restriction scenarios.

Any potential impacts on human health from the reduction in emissions of 1,4-dioxane resulting from the restriction scenarios have not been considered, as they are not in scope of this assessment. Other non-environmental social implications are also out of scope.

These conclusions do not support the adoption of either of the restriction scenarios considered in this Study and suggest that other more cost-effective measures should be explored and defined.

CONTENTS

Appendices

1. INTRODUCTION

The European Committee of Organic Surfactants and their intermediates (CESIO) has commissioned Ricardo to provide an independent **Socio-Economic Analysis (SEA) of proposals for the REACH restriction of 1,4-dioxane in surfactants for the EU-27**. The study follows the SEA guidelines produced by ECHA for REACH restrictions[6].

1.1 AIMS AND SCOPE OF THE SEA

The aim of this SEA is to assess quantitatively to the extent that is possible, or qualitatively where necessary, the **economic and environmental impacts** on **surfactant manufacturers and importers** and selected downstream sectors. The scope of the SEA is described in the Table below. **Social and human health impacts** are out of scope of this assessment. The baseline and the two restriction scenarios in scope are described in more detail in Section 3.

Table 1-1 Scope of this SEA

Scope	Details
Surfactants	Ethoxylated (EO)-based surfactants that contain 1,4-dioxane as an impurity
Downstream sectors	• Cosmetics and personal care products • Paints, Coatings, Adhesives, Elastomers, and Printing Inks* • Detergents and cleaning products • Agrochemical products and applications • Chemical products for textile and leather sectors
Categories of impact	This SEA only covers economic and environmental (social) impacts. Non-environmental social and human health impacts are out of scope of the assessment.
Geographical scope	EU-27
Time period	2026-2040

*Note: This downstream sector is more complex than the others as it covers more than one step in the value chain, i.e., the manufacturers of dispersions as well as those manufacturing final formulations for the named uses from these dispersions.

Surfactants are also used across other downstream sectors, such as lubricants, metal working, oilfield and mining, construction products, and pharmaceutical products, but could not be included in the Study due to their limited participation in the targeted stakeholder consultation.

Within this SEA, **only the contributions of 1,4-dioxane emissions of surfactants to the environment have been assessed**. There are other potential sources of 1,4-dioxane emissions to the environment which are discussed in the literature which are out of scope of this SEA. For example, within the Regulatory Management Option Analysis (RMOA) document for 1,4-dioxane, the sources of 1,4-dioxane discussed include the intentional use of 1,4-dioxane as a solvent and as an impurity and/or constituent of substances which have high economic impact and are also produced in large quantities[1]. 1,4-dioxane is formed as an impurity from different substances, such as surfactants among others, which are synthesised using ethoxylation. This is noted in the EU Risk Assessment for 1,4-dioxane[7], as well as in the more recent Risk Management Option Analysis[8].

[6] ECHA (2008). Guidance on Socio-Economic Analysis – Restrictions. Available from: https://echa.europa.eu/documents/10162/2324906/sea_restrictions_en.pdf/2d7c8e06-b5dd-40fc-b646-3467b5082a9d

[7] European Communities (2002). European Union Risk Assessment 1,4-Dioxane. Available from: https://echa.europa.eu/documents/10162/a4e83a6a-c421-4243-a8df-3e84893082aa

[8] BAuA (2020). Risk Management Option Analysis Conclusion Document 1,4-dioxane. Available from: https://echa.europa.eu/documents/10162/010b37a1-9d0d-a69e-a703-df8626102fae

1.2 STRUCTURE OF THE SEA

This rest of this SEA is structured in five sections and followed by a set of complementary Annexes. The sections include:

- Section 2, providing an overview of the SEA methodology.
- Section 3, describing the baseline and restriction scenarios.
- Section 4, summarising the analysis of economic and environmental impacts.
- Section 5, comparing the restriction scenarios based on their potential impacts, and considering any sensitivities to the assumptions employed in the assessment.
- Appendices, comprising a detailed description of the methodologies employed, the definition of the sectors analysed, technical description of surfactants and the formation of 1,4-dioxane, the outputs of an evidence review of alternatives, and the consultation synopsis.

2. OVERVIEW OF THE METHODOLOGY

A **five-step approach** has been employed to assess the socio-economic impacts of each restriction scenario, following ECHA's guidelines. These steps are:

- Step 1: Defining the baseline and restriction scenarios under consideration.
- Step 2: Mapping and screening all potential impacts of the restriction scenarios, based on the estimated absolute and relative magnitude of these impacts and their likelihood, based on the available evidence.
- Step 3: Gathering primary and secondary evidence to support the analysis.
- Step 4: Assessing the shortlisted socio-economic impacts, qualitatively and/or quantitatively.
- Step 5: Reviewing key uncertainties and conducting sensitivity analysis.

These are described briefly in the following sections with more detailed information on the methodology presented in Appendix 1.

2.1 STEP 1: DEFINING THE BASELINE AND RESTRICTION SCENARIOS

This SEA closely follows ECHA's guidance on SEA for REACH restriction proposals[9]. In accordance with the guidance, a baseline (or 'do nothing') scenario has been defined, against which two proposed restriction scenarios are analysed. These scenarios were defined in discussions with CESIO as follows:

- **Baseline scenario**: This scenario assumes that no new restrictions under REACH would be introduced. As a result, historical trends of key economic indicators (such as production in the EU-27, imports into the EU-27, exports out of the EU-27 and employment) are used to estimate a possible future pathway to 2040, for the economic sectors in scope. Similarly, evidence of environmental indicators (such as emissions of 1,4-dioxane from EO-based surfactants) has been reviewed to estimate how attributable emissions of 1,4-dioxane could evolve. The baseline scenario is described in Section 3.1.
- **Restriction scenarios**: The scope of the project comprises two restriction scenarios. The two scenarios were developed by drawing on the sectoral expertise within CESIO, Ricardo's team and the information that has been made publicly available by regulators and public authorities to date concerning the potential restrictions which might be under consideration. It has been assumed that any of the restriction scenarios would apply to manufacturing and/or placing on the market in the EU any surfactants that do not meet the set criteria. Moreover, the proposed restrictions have been defined against the level of impurity of 1,4-dioxane in surfactant active matter within surfactant products, which has been considered, from a regulatory perspective, to offer a 'consistent' and relatively effective basis for restricting the level of 1,4-dioxane impurities across diverse value chains. These scenarios are outlined in Section 3.2.

2.2 STEP 2: MAPPING AND SCREENING OF IMPACTS

A longlist of potential impacts for the two restriction scenarios against the baseline have been mapped across two categories (economic and environmental impacts) using impact pathway and theory of change approaches. Please note that non-environmental social impacts are out of scope and thus, as a result, not considered as part of the mapping and screening exercise, nor the SEA more generally.

This longlist of impacts was screened, using a qualitative framework that considered their likelihood to materialise or occur, and the potential magnitude (and direction) of impact, based on the available evidence. The output of this task has been a shortlist of 17 categories (see Appendix 1, Sections A1.2 and A1.3) for an in-depth assessment of impacts of the two restriction scenarios against the baseline.

2.3 STEP 3: GATHERING EVIDENCE

Two information-gathering exercises have been conducted to support this SEA. These are:

[9] ECHA (2008). Guidance on Socio-Economic Analysis – Restrictions. Available from: echa.europa.eu/documents/10162/23036412/sea_restrictions_en.pdf/2d7c8e06-b5dd-40fc-b646-3467b5082a9d

- **Stakeholder consultation**. Two online surveys were conducted targeting **manufacturers and/importers of surfactants** and **downstream users of surfactants** from the economic sectors in scope. These surveys asked companies to provide information on, for example, their baseline activity (such as number of employees, tonnages manufactured/imported, sales turnover, research and development, etc.), the presence of 1,4-dioxane in surfactant active matter manufactured and/or used in the manufacturing of products, any alternatives to their baseline products, how they might respond to the proposed restriction (e.g., adjustment, substitution, etc.), and evidence on the management and treatment of wastewater. A brief consultation synopsis is presented in Appendix 6.
- **Desk-based research**. A research task was designed and conducted to identify and review relevant published material, such as industry reports and the scientific literature. This assessment was both quantitative and qualitative in nature. The research targeted and gathered evidence on the sectoral economic baseline (especially by drawing on Eurostat and published industry reports), the levels of 1,4-dioxane in surfactants/products, potential alternatives (including technologies to remove 1,4-dioxane impurities and other product alternatives), the performance of baseline and alternative products, waste and wastewater treatment, and the emissions of 1,4-dioxane into the environment. A more detailed summary of the approach employed is summarised in Appendix 1 and the outputs concerning the evidence review of product alternatives in Appendix 5.

The study's methodologies are described in more detail in the Appendices.

2.4 STEP 4: ASSESSING IMPACTS

The shortlisted impacts for each restriction scenario against the baseline have been assessed qualitatively, and where possible quantitatively, to compare the costs and benefits and, ultimately, develop conclusions and policy recommendations.

Qualitative and quantitative methods in alignment with the ECHA SEA restriction guidance are proposed to characterise the impacts over the period of 2026-2040.

- **The impacts of the restriction scenarios against the baseline have been quantified, where evidence was available**. For example, quantitative analysis has been performed to estimate: i) the level of economic activity in the EU-27 that would require some type of transformation (e.g., substitution and/or product adjustment) across the value chains in scope, and the compliance (capital and operating) costs that would be incurred to achieve this; and ii) the emissions of 1,4-dioxane into the environment, under each restriction scenario against the baseline.
- **The impacts of the restriction scenarios against the baseline have been qualitatively assessed (including the direction and relative magnitude), where evidence was not available**. Qualitative methods also allow for bringing the overall assessment together to develop conclusions. For example, the evidence available was considered to establish a relative magnitude and direction of impact for the EU industry's competitiveness in a global context, considering the effects on costs of doing business and trade, drawing on the Commission's Better Regulation[10] and ECHA's guidelines. A qualitative analysis has also been conducted to conclude on the effects of the restriction scenarios against the baseline on the use of resources (e.g., energy) and waste production and treatment.

The outputs of the assessment were used to establish comparable and evidence-based 'scores', following a scale of -5 to +5 to reflect the direction (positive or negative) and the magnitude of impact (weakly: 1 to strongly: 5, limited: 0 or unclear impacts: N/A), which are illustrated in Table 2-1. This methodology, based on Multi-Criteria Decision Analysis, required an iterative and multidisciplinary approach that is detailed in Appendix 1.

Table 2-1 Scoring and colour-coding framework used for the overall, qualitative assessment

Strongly negative	Negative	Weakly negative	No or limited impact	Weakly positive	Positive	Strongly positive	Unclear
-5	-3	-1	0	+1	+3	+5	N/A

[10] European Commission (2024) Better regulation: guidelines and toolbox. Available from: https://commission.europa.eu/law/law-making-process/planning-and-proposing-law/better-regulation/better-regulation-guidelines-and-toolbox_en

2.5 STEP 5: UNCERTAINTIES AND SENSITIVITY ANALYSIS

The evidence gathered and analytical outputs are uncertain. There are inherent uncertainties in *ex-ante* assessments, which in this case are exacerbated by limitations in the evidence availability. The sensitivity of the conclusions of the SEA were tested against these uncertainties by exploring whether possible (but unlikely) 'low' and 'high' scenarios might affect, if at all, the outputs of the SEA. The sensitivity analysis was conducted as follows:

- **The distribution of responses to the stakeholder consultation was reviewed to derive possible (but unlikely) estimates corresponding to 'low' and 'high' impact scenarios**, which captured the uncertainties in the business responses to the REACH restriction proposal scenarios. For example, the sensitivity of the results the levels of 1,4-dioxane associated with the production activity of various segments of the surfactants value chain, the extent to which businesses may be able to substitute and/or adjust their products with no or low levels of 1,4-dioxane and the potential costs of transformation have been explored. These estimates have been presented in Section 4.1.
- **The impacts of the restriction scenarios against the baseline were estimated under the 'high' and 'low' impact scenarios** to evaluate the sensitivity of the conclusions of this Study to any inherent uncertainties in the data.
- **The scale and direction of the impacts were compared to the impacts under the likely central estimate, which represents the most likely scenario**. Sensitivities to the overall conclusions have been considered in Section 5.2.

3. BASELINE AND PROPOSED RESTRICTION SCENARIOS

This section describes the baseline scenario and the two proposed restriction scenarios considered in this SEA.

3.1 DEFINITION OF THE BASELINE SCENARIO

This section introduces the substance 1,4-dioxane, the surfactant products in scope of assessment, their market and value chain, and the current regulatory framework.

3.1.1 1,4-dioxane

1,4-dioxane is used as a solvent in the manufacturing of chemicals and is also an impurity that can be formed during manufacturing, such as in the manufacturing of the Ethoxylated (EO)-based surfactants.

The focus of this SEA is on 1,4-dioxane as an impurity in surfactants. However, information on the uses of 1,4-dioxane are provided as context for the baseline. In its REACH registration dossier, 1,4-dioxane is used as a solvent and in laboratories in industrial and professional settings with no listed consumer uses[11]. This includes being used as an intermediate, in the formulation of mixtures, used as a solvent in the manufacturing of other chemicals and use as laboratory chemical.

The release of 1,4-dioxane to the environment can occur from its use as a processing aid at industrial sites, its use as an intermediate and its use in the production of articles[12]. Historically, 1,4-dioxane (~90%) has been used as a stabiliser in chlorinated solvents[11].

1,4-dioxane can be harmful to human and environmental health. 1,4-dioxane is classified as a carcinogenic (Carc, 1B, H350) substance in the EU, with an occupational exposure limit (OEL) based on systemic effects in the kidney and also for nasal irritation effects which could lead to carcinogenicity and effects on the liver (human health is out of scope for this SEA and is provided here for background information only[13]). For environmental effects, ECHA have concluded that the persistence, mobility and long-range transport potential of 1,4-dioxane gives rise to concerns that 1,4-dioxane can lead to an irreversible presence in the environment, which in turn could lead to contamination of aquatic environments[14].

Table 3-1 Information on 1,4-dioxane[15,16].

Heading	Details
EC number	204-661-8
CAS number	123-91-1
Molecular formula	$C_4H_8O_2$
Molecular weight	88.12 g/mol

[11] ECHA (2022). Annex 1 in support of the Committee for Risk Assessment (RAC) for evaluation of limit values for 1,4-dioxane at the workplace. Available from: https://echa.europa.eu/documents/10162/073d44ca-5ad2-8128-fd15-8c74a4bdb126

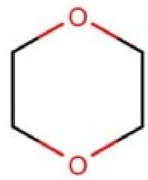
[12] ECHA (n.d.). 1,4-dioxane Substance Infocard. Available from: https://echa.europa.eu/substance-information/-/substanceinfo/100.004.239

[13] ECHA (2022). Opinion on scientific evaluation of occupational exposure limits for 1,4-dioxane. Available from: https://echa.europa.eu/documents/10162/7937606/1_final_opinion_oel_1_4_dioxane_en.pdf/686365df-9485-c2ac-b342-289ec306d188?t=1656313877233

[14] ECHA (2021). Proposal for Identification of Very High Concern on the Basis of the Criteria set out in REACH Article 57. Available from: https://echa.europa.eu/documents/10162/435f5245-3bad-5ff5-65f3-0b279c9b6847

[15] ECHA (2022). Annex 1 in support of the Committee for Risk Assessment (RAC) for evaluation of limit values for 1,4-dioxane at the workplace. Available from: https://echa.europa.eu/documents/10162/073d44ca-5ad2-8128-fd15-8c74a4bdb126

[16] ECHA (2021). Proposal for Identification of Very High Concern on the Basis of the Criteria set out in REACH Article 57. Available from: https://echa.europa.eu/documents/10162/435f5245-3bad-5ff5-65f3-0b279c9b6847

Heading	Details
Chemical structure	
Density	1.0336 g/cm^3 (20 °C)
Partition coefficient (log Pow)	-0.42 (20 °C)
Water solubility	Completely miscible at 20 °C
Viscosity	1.31 mPa*s (20 °C)

Reported levels of 1,4-dioxane in the environment include concentrations of around 0.05-1 µg/L in surface water, groundwater, bank filtrate and raw water in 2020-2021 in Germany[17]; concentrations reported in the Rhine between 0.098-1.42 µg/L[18]; and levels between n.d.- 1.68 µg/L in fresh drinking water[19] and n.d.-5.60 µg/L in Germany for sampling undertaken in 2017-2018[20].

3.1.2 Surfactant products

Surfactants have been defined by CESIO as "*any surface-active organic substance or mixture which consists of one or more hydrophilic groups of such a nature and size that is capable of fulfilling both of the following criteria:*[21]

- *Forms a clear micellar solution or a translucent microemulsion or stable emission without the separation of insoluble matter when mixed with water at a concentration of 0.5 wt.% and left to stand for one hour at 20 °C;*
- *Reduces the surface tension of water to <45 mN/m at a concentration of 0.5 wt.% at 20 °C.*"

There is currently no definition for surfactants or surfactant products in REACH. 1,4-dioxane is formed as an unintended by-product during the manufacturing of ethoxylated surfactants. Surfactants are organic compounds, which are composed of two chemical parts. These two chemical parts have different polarities and are composed of a head group and a tail group. The head group has an affinity for polar phases whereas the tail group has an affinity for nonpolar phases (amphiphilic nature). Surfactants can be used to reduce both the interfacial and surface tension between two (or more) phases due to their structure. Surfactants also generate self-assembled structures when in solution leading to micelle formations. Due to these properties, including their amphiphilic nature, surfactants can both mobilise and combine materials that would not normally mix due to their incompatible molecular properties.

Surfactants are used for the following major properties:

- Emulsifying or dispersing power
- Foaming/Defoaming
- Reducing surface tension
- Suspending/stabilising power
- Wetting[22].

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[17] Kim DH, Ait Bamai Y, Belova L, Bessems J, Poma G, Covaci A. (2023). Human exposure to persistent and mobile chemicals: A review of sources, internal levels and health implications. Sci Total Environ.;893:164764.

[18] RIWA (2021). Annual Report 2020 The Rhine. Available from: https://www.riwa-rijn.org/wp-content/uploads/2021/10/RIWA-2021-EN-Anual-Report-2020-The-Rhine.pdf

[19] Karges U, Ott D, De Boer S, Püttmann W. (2022). 1,4-Dioxane contamination of German drinking water obtained by managed aquifer recharge systems: Distribution and main influencing factors. Sci Total Environ. 711:134783

[20] Karges U, de Boer S, Vogel AL, Püttmann W. (2022) Implementation of initial emission mitigation measures for 1,4-dioxane in Germany: Are they taking effect? Sci Total Environ. 806(4):150701

[21] CESIO (2023). Call for evidence on a possible restriction of 1,4-dioxane containing surfactants. Response to BAuA. Dated 17 July 2023.

[22] CESIO (2024). What are surfactants? Available from: https://www.cesio.eu/index.php/about-surfactants/what-are-surfactants

EO-based surfactants are used in a wide variety of applications/sectors including for agrochemical applications; cosmetics and personal care products; detergents and cleaning products; paints, elastomers and printing inks; lubricants, metal working, oilfield/mining; construction products; pharmaceutical products; and textile and leather products. EO-based surfactants include anionics and non-ionics, as described in the Table below. Detailed explanations on the uses of EO-based surfactants and the formation of 1,4-dioxane are provided in Appendix 3.

Table 3-2 Ethoxylate (EO)-based surfactants. Source: Stakeholder consultation.

Primary Grouping	Surfactants
Anionics	Alkyl ether sulfates; alkyl ether carboxylates; alkyl ether phosphates; sulfosuccinates
Non-ionics	Fatty alcohol ethoxylates; fatty acid ethoxylates; fatty acid esters, ethoxylated – alkyl ether carboxylates and derivates; fatty amine ethoxylates; alkyl mixed alkoxylates; ethoxylated/propoxylated (EO/PO) copolymers

1,4-dioxane is present as an unintended impurity in Ethoxylated (EO)-based surfactants as a result of the synthesis process. 1,4-dioxane can be formed as a result of the dimerisation of ethylene oxide.[23] The manufacturing of derivatives like alkyl ether sulfates and phosphates can also promote the formation of 1,4-dioxane from the reaction of alkyl ethoxylates and sulphur trioxide.[24] Reported levels of 1,4-dioxane in products containing EO-based surfactants include 0.03-32 ppm in cleaning products[25]; 0.66-56 ppm in cleaning agents[26]; and levels below 10 ppm in cosmetic cleansing products[27].

Currently used surfactants on the EU-27 market are listed in Table 3-3 along with their average estimated 1,4-dioxane level provided from the SEA consultation. The table also lists the key sector for each surfactant, this information is useful when considering the properties required for each sector and thus required from any alternatives. The degree of ethoxylation of surfactants affects the uses of the surfactants, with the function of the surfactant dependent on this. For example, for detergents medium EO-surfactants are required [28].

Table 3-3 The surfactants impacted by the restriction scenarios and their respective key sectors of use.

Primary Grouping	Most frequently reported use sector	Other sectors of use	Most frequent estimation of concentration
Anionics			
Alkyl ether sulfates	Cosmetics and personal care	Detergents and cleaning products Paints, coatings, adhesives, elastomers, and printing inks	>10 ppm
Alkyl ether carboxylates	Detergents and cleaning products	Lubricants, metal working, oilfield/mining	Between 1 ppm and 10 ppm
Alkyl ether phosphates	Agrochemical applications	Paints, coatings, adhesives, elastomers, and printing inks, metal working	>10 ppm
Alkyl ether carboxylates and	Cosmetics and personal care		Between 1 ppm and 10 ppm

[23] A Salvador and A Chisvert (eds) (2007). Analysis of Cosmetic Products, Elsevier. Available from: https://www.sciencedirect.com/book/9780444522603/analysis-of-cosmetic-products

[24] Teknoscienze Srl (2024). What's all the fuss about 1,4-dioxane? Available from: https://www.teknoscienze.com/tks_article/whats-all-the-fuss-about-14-dioxane/#:~:text=1%2C4%2DDioxane%20can%20also,%2C4%2Ddioxane%2C%20giving%20detectable

[25] Hayes et al (2023): Precise measurement of 1,4-dioxane concentration in cleaning products: A review of the current state-of-the-art. Journal of Surfactants and Detergents, 25(6): 729-741. Available from: https://aocs.onlinelibrary.wiley.com/doi/full/10.1002/jsde.12674

[26] Palumbo B, Conrad-Vlasak D, Stanton K (2023) A novel protocol for quantitative determination of 1,4-dioxane in finished cleaning products. Journal of Surfactants and Detergents. Available from: https://aocs.onlinelibrary.wiley.com/doi/full/10.1002/jsde.12674

[27] Tahara M, Obama T, Ikarashi Y. (2013). Development of analytical method for determination of 1,4-dioxane in cleansing products. Int J Cosmet Sci. 35(6):575-80.

[28] Ricardo (2024). CESIO Response to the UBA Questionnaire. Final Report.

Primary Grouping	Most frequently reported use sector	Other sectors of use	Most frequent estimation of concentration
derivatives – i.e. Sulphosuccinates -			
Other anionics	Cosmetics and personal care	Other	<1 ppm
Non-ionics			
Fatty alcohol ethoxylates	Detergents and cleaning products	Chemical products for textile and leather	Between 1 ppm and 10 ppm
a. Natural	Detergents and cleaning products		Between 1 ppm and 10 ppm
b. Synthetic	Detergents and cleaning products		Between 1 ppm and 10 ppm
Fatty acid ethoxylates	Chemical products for textile and leather	Detergents and cleaning products	>10 ppm
Fatty acid esters, ethoxylated - Alkyl ether carboxylates and derivatives	Cosmetics and personal care	Chemical products for textile and leather	>10 ppm
Fatty amine ethoxylates	Detergents and cleaning products	Chemical products for textile and leather	>10 ppm
Alkyl mixed alkoxylates	Detergents and cleaning products	Chemical products for textile and leather	Between 1 ppm and 10 ppm
EO/PO copolymers	Cosmetics and personal care	Detergents and cleaning products	Between 1 ppm and 10 ppm
Other ethoxylates	Cosmetics and personal care		Between 1 ppm and 10 ppm

Surfactants are used across many sectors, for example:

- **Cosmetics and personal care:** Surfactant products are used to create lather or foam, to soften, lubricate and moisturise the skin, to form a protective layer for hair, lips, nails, and to disperse pigments and perfumes. They also contribute to general needs for hygiene such as handwash, as recently highlighted during the COVID-19 pandemic. Example of products include liquid soap, body wash, shampoo and conditioner, toothpaste, skin creams and lotions, and sunscreen.
- **Paints, Coatings, Adhesives, Elastomers, and Printing inks**: Surfactant products are used to stabilise and disperse pigments, as well as homogenise formulations, and to enable emulsion polymerisation. Surfactants also act as defoamers allowing for smooth spray application. Additionally, surfactants enhance the finish of paints by acting as levelling agents to achieve a smooth surface.
- **Detergents and cleaning products**: Surfactant products are necessary to remove dirt and oils from surfaces and fabrics. Example products include laundry detergents, fabric conditioners, dish washing detergent, hard floor and surface cleaners.
- **Agrochemical applications**: Surfactant products facilitate and accentuate the emulsifying, dispersing, spreading, wetting, or other surface modifying properties of crop care liquids. The surfactants breakdown the surface tension on waxy plant surfaces. Over all the surfactants aid the application process to benefit the effectiveness of the products.
- **Chemical products for textile and leather**: Surfactant products are complementary to many other chemicals that are necessary to clean and treat the textiles through smoothing surfaces, treating fabrics for further processing, flameproofing and waterproofing.

Surfactants are also used across other downstream sectors, such as lubricants, metal working, oilfield and mining, construction products, and pharmaceutical products, but could not be assessed in the Study due to their limited participation in the targeted stakeholder consultation.

In summary, as illustrated above, surfactants can alter the interfacial tension between a liquid and other liquids, air and solids; have wetting, foaming/defoaming, emulsifying, suspending and or stabilising power; and an ability to mobilise immiscible substances. Thus, surfactants serve a wide range of functions across many downstream sectors and can especially increase the effectiveness and efficiency of processes, reducing water and energy usage.

3.1.3 The surfactants' economic value chain in EU-27

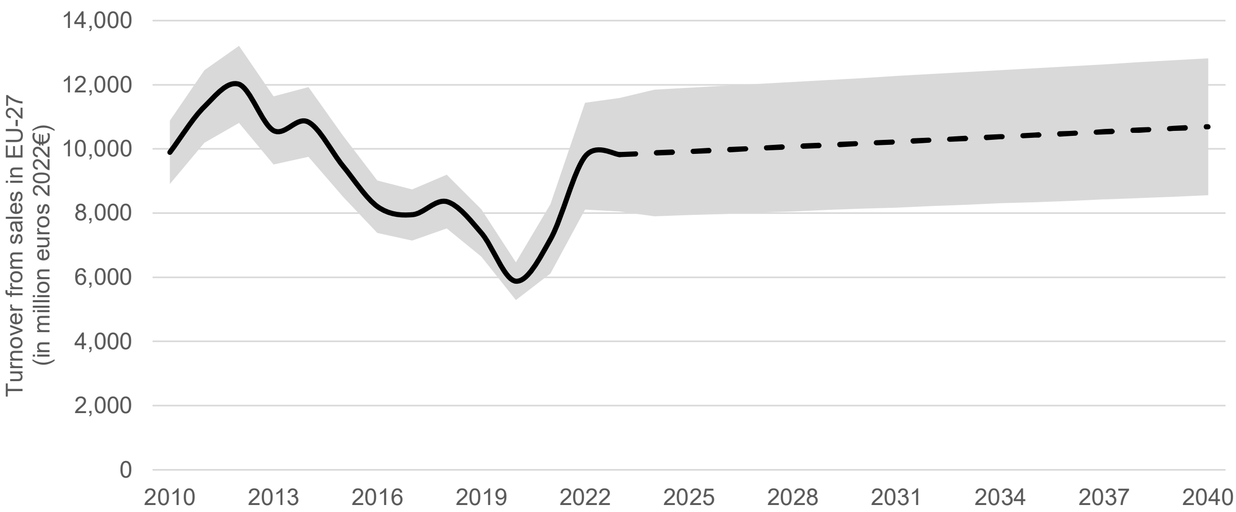
This section describes the EU-27 market of surfactants and selected immediate downstream markets, in terms of their size (e.g., sales turnover), investments and expenditures, trade and employment.

3.1.3.1 The size of the market in the EU-27 (sales turnover)

Surfactants play a notable role in the EU-27 economy and have a diverse range of applications, in many cases critical, spanning multiple 'downstream user' sectors.

The turnover from sales of surfactants in the EU-27 has been estimated at around €10 billion in 2022, ranging from €8 to €11 billion. The EU surfactants' market has fluctuated in recent years. A Study by Market Data Forecast[29] suggests that the 'European market' of surfactants is valued at around €9-10 billion euros in 2023 (in constant 2022 euros), with a potential to reach around €17-18 billion by 2028 (in constant 2022 euros)[30]. However, based on the historical and available evidence, it is assumed that the sales turnover and manufacturing activity would remain of a similar size, in real terms, in the future. We have thus estimated the industry may reach sales turnover of around €11 billion by 2040 (in constant 2022 euros), ranging from around €9 to €13 billion. This is presented in Figure 3-1 below.

Figure 3-1 Baseline sales turnover of surfactants in the EU-27 (€ million)



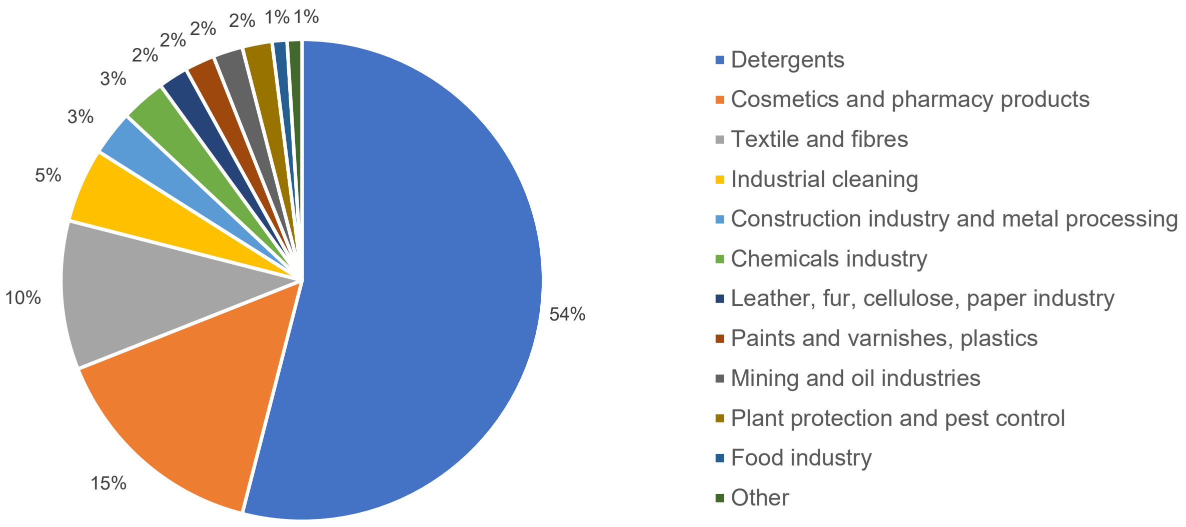
Source: Ricardo analysis based on Eurostat data (PRODCOM and SBS) and expert input and validation by CESIO. Values are provided in 2022 prices.

As noted, surfactant applications are diverse. Figure 3-2 overleaf provides a breakdown of the total consumption of surfactants by the relevant downstream user markets in Western Europe.

[29] Market Data Forecast (2023). Europe Surfactants Market. Available from: https://www.marketdataforecast.com/market-reports/europe-surfactants-market

[30] As per the Study, the Europe surfactants market is expected to reach a valuation of €19-20 billion in 2028, which is assumed to be in nominal terms and adjusted based on the GDP deflator to €17-18 billion (in constant 2022 euros).

Figure 3-2 Surfactant applications across sectors in Western Europe (% of total consumption of surfactants)



Source: CESIO, translated from German using translate.google.com

This study has focussed on five downstream user sectors, prioritised based on the: 1) proportion of total surfactants consumed by the sector; 2) criticality of the role of surfactants in the sector; 3) relevance of the downstream sector; and 4) sufficient (i.e., 5 or more) responses to the stakeholder consultation conducted for this study.

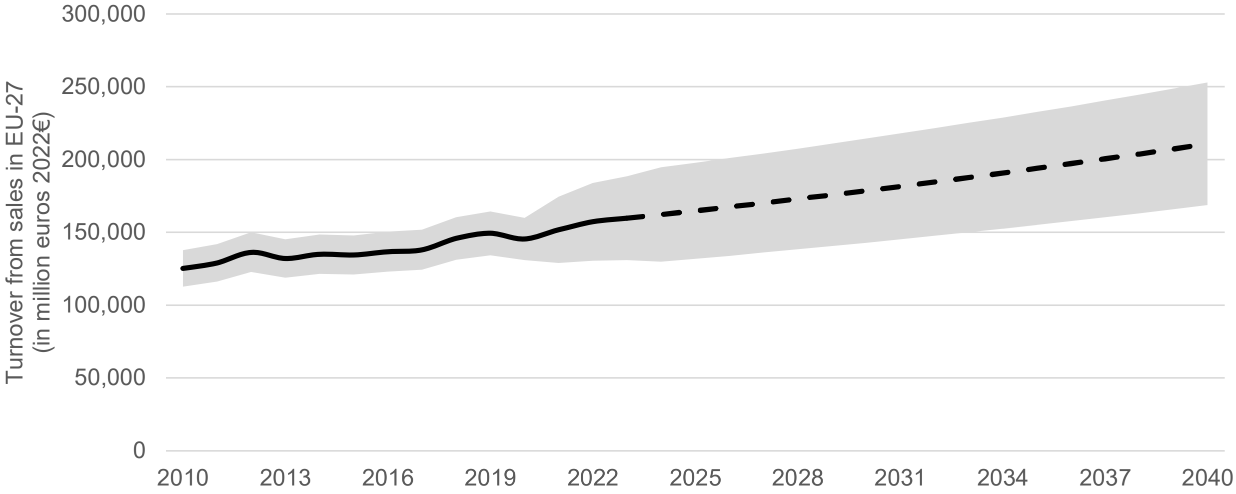
Together, **the five, selected 'downstream users' sectors in scope account for over 80% of the consumption of surfactants in Western Europe**. These are:

- Cosmetics and personal care products
- Paints, Coatings, Adhesives, Elastomers, and Printing Inks
- Detergents and cleaning products
- Agrochemical products and applications
- Chemical products for textiles and leather sector

The sales turnover of these five downstream user sectors has been estimated at around €160 billion in 2022. Over the period 2010-2022, the downstream user industry in the EU-27 has grown, with an average real Compound Annual Growth Rate (CAGR) of around +2.0%. Based on expert elicitation and the analysis of available evidence, a real CAGR of around +1.5% has been assumed for the future[31]. This would imply that, over the coming decade, the sales turnover of the downstream user industries in scope might surpass €200 billion by 2040 (in constant 2022 euros). The baseline data and forecast for the sales turnover of downstream activity are presented in Figure 3-3 below.

[31] Please note that the relationship between the surfactants market and downstream user market growth has generally remained steady, albeit it has fluctuated in recent years due to short-term dynamics in the surfactants market. It is not clear, however, whether there might be decoupling of the manufacturing/importing trends between the upstream surfactants market and the selected downstream sectors. This has not been explored in depth, and it is not a conclusion of this Study. This Study aims to characterise the baseline for the sole purpose of estimating the scale of potential impacts of the restriction scenarios. In this case, it has been assumed that the surfactants market might remain of a similar size in the future, in real term, and uncertainties around this have been quantified. Despite this, positive growth has been assumed for the downstream user sectors in scope based on historical data from Eurostat.

Figure 3-3 Baseline sales turnover of 'downstream user' products in the EU-27 (€ million)



Source: Ricardo analysis based on Eurostat data (PRODCOM and SBS) and expert input and validation by CESIO. Values are provided in 2022 prices.

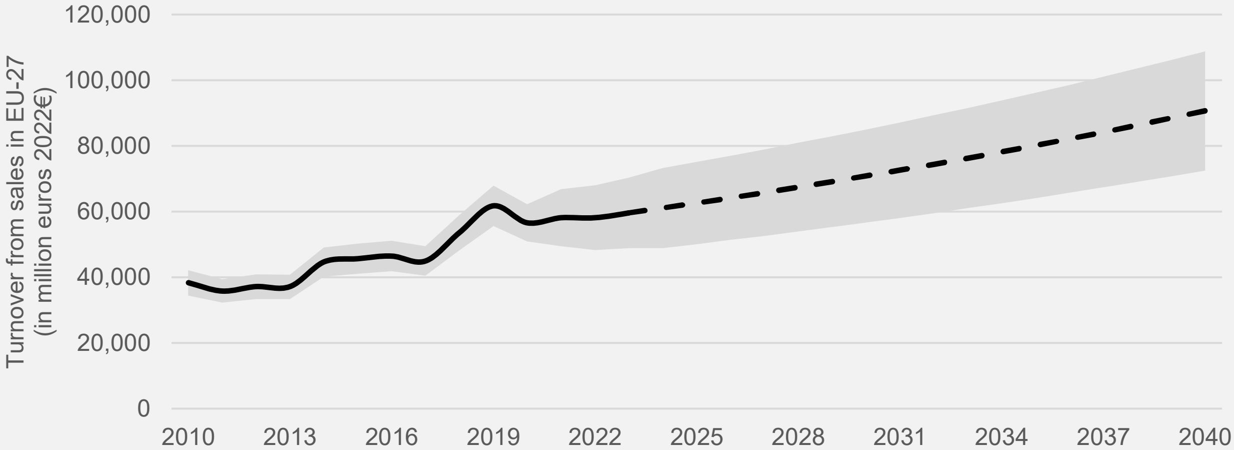
The baseline data and forecasts for the sales turnover for each downstream user sector are presented in the Box below.

Box 3-1 Baseline sales turnover of the production of specific 'downstream user' sectors in scope in the EU-27

Cosmetics and personal care products

The sales turnover of the cosmetics and personal care products market in the EU-27 was estimated at €58 billion in 2022. Sales turnover in this market is estimated to grow at a real CAGR of +2.5% in the coming years, potentially reaching sales turnover of over €90 billion by 2040 (in constant 2022 euros).

Figure 3-4 Baseline turnover from sales of cosmetics and personal care products in the EU-27 (€ million)

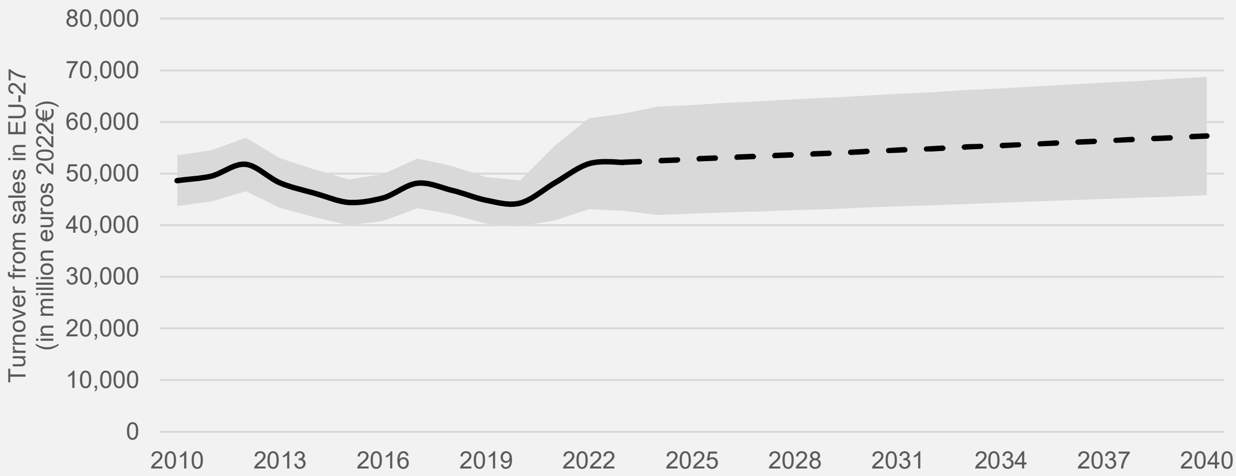


Source: Ricardo analysis based on Eurostat data (PRODCOM and SBS) and expert input and validation by CESIO. Values are provided in 2022 prices.

Paints, Coatings, Adhesives, Elastomers and Printing Inks

The sales turnover of the paints, coatings, adhesives, elastomers, and printing inks market in the EU-27 was estimated at €52 billion in 2022. The sales turnover in this market has fluctuated in recent years but is estimated to grow slightly in the coming years, in real terms, potentially reaching a sales turnover of around €57 billion by 2040 (in constant 2022 euros).

Figure 3-5 Baseline turnover from sales of paints, coatings, adhesives, elastomers and printing inks in the EU-27 (€ million)

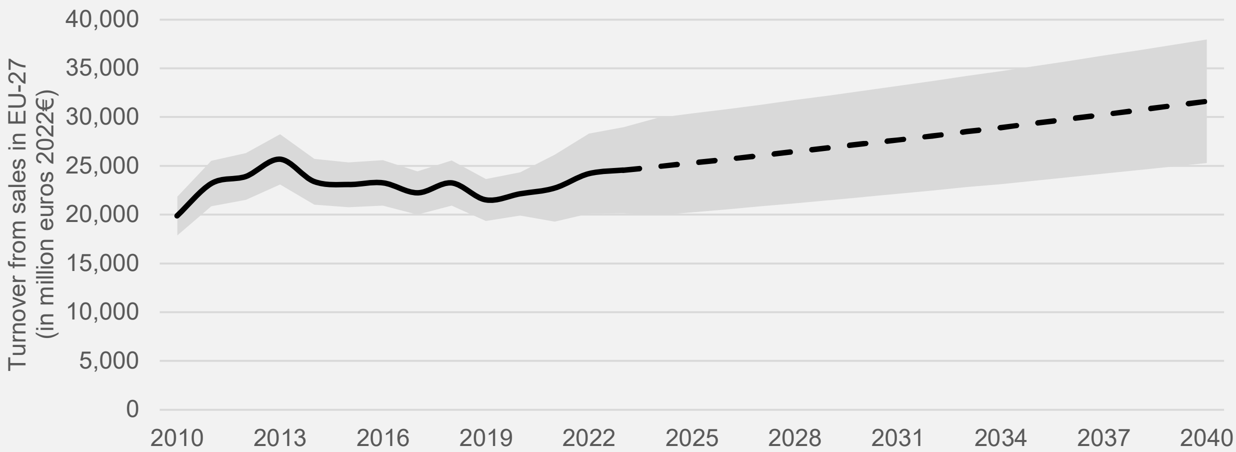


Source: Ricardo analysis based on Eurostat data (PRODCOM and SBS) and expert input and validation by CESIO. Values are provided in 2022 prices.

Detergents and cleaning products

The sales turnover of the detergents and cleaning products market in the EU-27 was estimated at €24 billion in 2022. The market has grown at a real CAGR of over +1.5% in recent years. It is estimated that it might continue to grow at a similar rate, potentially reaching over €30 billion in sales turnover by 2040 (in constant 2022 euros).

Figure 3-6 Baseline turnover from sales of detergents and cleaning products in the EU-27 (€ million)

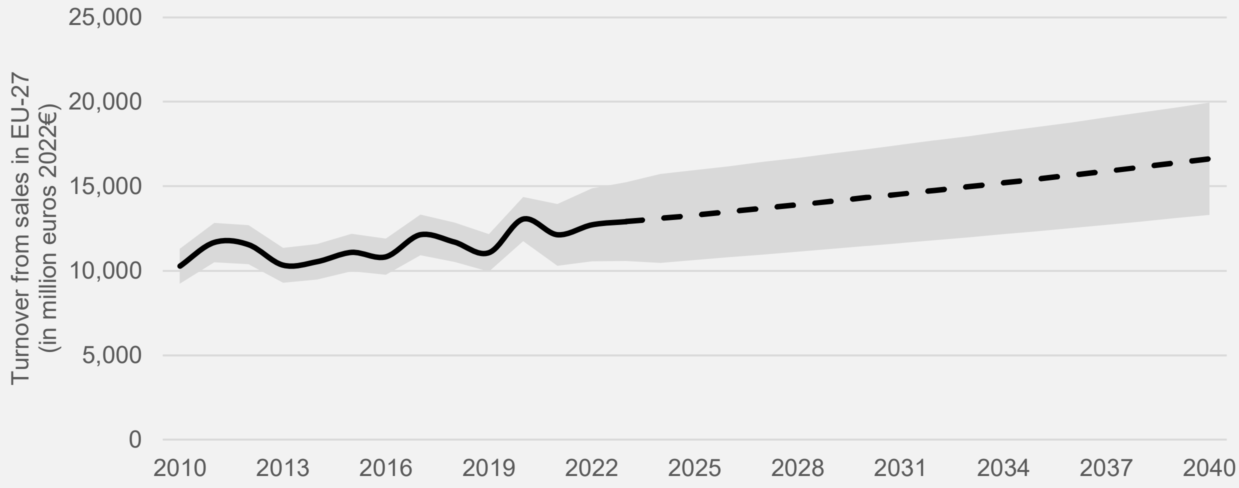


Source: Ricardo analysis based on Eurostat data (PRODCOM and SBS) and expert input and validation by CESIO. Values are provided in 2022 prices.

Agrochemical products and applications

The sales turnover of the agrochemical products and applications market in the EU-27 was estimated at €13 billion in 2022. The market has grown at a real CAGR of under +2.0% in recent years and will continue to grow at a similar rate in the future, potentially reaching a sales turnover of around €17 billion by 2040 (in constant 2022 euros).

Figure 3-7 Baseline turnover from sales of agrochemical products and applications in the EU-27 (€ million)

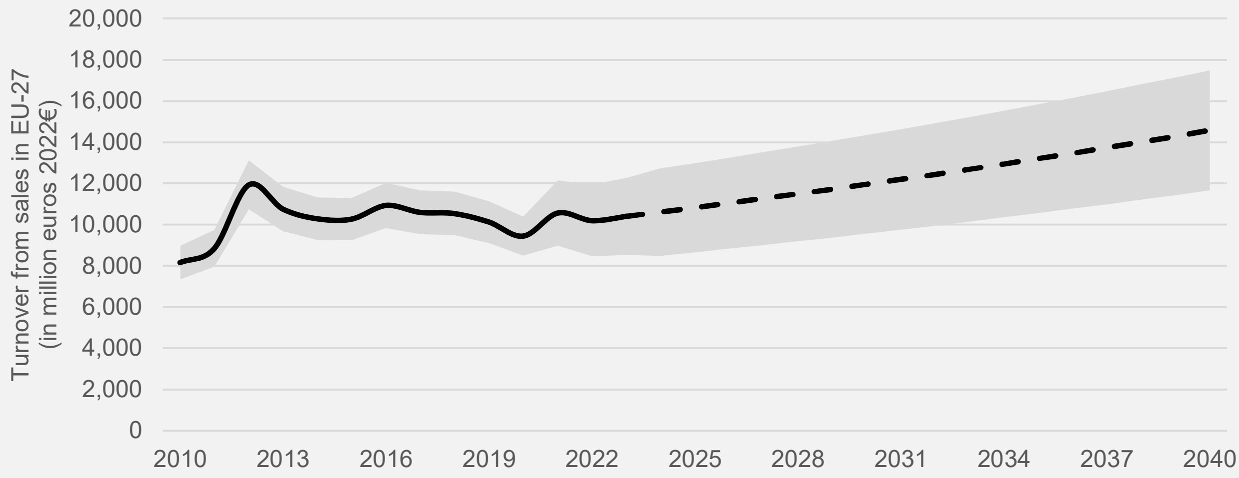


Source: Ricardo analysis based on Eurostat data (PRODCOM and SBS) and expert input and validation by CESIO. Values are provided in 2022 prices.

Chemical products for textiles and leather

The sales turnover of the Chemical products for textiles and leather market in the EU-27 was estimated at €10 billion in 2022. The market has grown at a real CAGR of around +2.0% in recent years. It is estimated that the market might grow at similar rate in the coming years, in real terms, potentially reaching a scale of around €15 billion by 2040 (in constant 2022 euros).

Figure 3-8 Baseline turnover from sales of chemical products for textiles and leather in the EU-27 (€ million)



Source: Ricardo analysis based on Eurostat data (PRODCOM and SBS) and expert input and validation by CESIO. Values are provided in 2022 prices.

Overall, the scale of manufacturing activity in the EU-27 across the suppliers of surfactants and downstream industries in scope of this study, as defined above, has been estimated to surpass an annual sales turnover of €170 billion (in constant 2022 euros[32]). This includes the manufacturing activity across upstream industries, that is, companies specialising in the production of surfactants; and 'downstream user' companies, which rely at least partly on these upstream products to manufacture components and/or final products for their sale in or export out of the EU-27.

In total, the suppliers of surfactants and downstream industries in scope of this study generated an estimated €47 billion of direct Gross Value Added (GVA) in 2022, approximately 30% of their production

[32] Please note that all euro figures presented in this study will be in constant 2022-euro terms.

value. This reflects the direct contributions of the surfactants industry and its downstream users (the 'value chain') to the EU-27 Gross Domestic Product (GDP), which is amplified by intermediate purchases of goods and services (the indirect effect) and the economic contribution of expenditures and consumption by the employees supported by this industrial activity (the induced effect). The total estimated footprint of this 'value chain' on the EU-27 economy, including the direct, indirect and induced effects, could surpass €90 billion of GVA[33]. It is assumed that GVA would continue to grow more or less in line with the industry's production value, in real terms, around +2-3% per annum.

Finally, the evidence also suggests that there are more than 15,000 firms operating in these upstream and downstream segments of the surfactants value chain. The majority of these firms are likely to be small and medium sized enterprises (SMEs). In 2022, around 99.8% of all enterprises in the EU-27 were SMEs[34], and these accounted for around 51.8% of the Gross Value Added to the EU-27 economy, which is aligned with the available evidence pertaining to the surfactants' value chain. A consultation of industry players within the upstream and downstream markets in scope of this Study was engaged primarily by larger firms, albeit some SMEs also participated (see Appendix 6 for the consultation synopsis).

3.1.3.2 Investments and expenditures

The investment in capital and operating expenditures of companies across these upstream and downstream industries are notable, with strong backward and forward links to the rest of the EU-27 economy. **In 2022, these industries invested over €6 billion in capital in the EU-27** (~€380 million of capital expenditure or CAPEX upstream and ~€6 billion across downstream user markets), which is equivalent to ~4% of their annual sales turnover.

The companies operating in these markets also purchased goods and services within the EU-27 and abroad to perform their manufacturing activities effectively. **In 2022, their operating expenditures (OPEX) in the EU-27 surpassed €145 billion** (~€8 billion of annual expenditures upstream and ~€140 billion across downstream user markets), which is equivalent to ~85-90% of their sales turnover value. These expenditures also include investments in Research and Development (R&D) within the EU-27, which plays a key role in progress and innovation at a global scale.

The baseline data and forecasts for the CAPEX and OPEX for each downstream user sector are presented in the Box below.

Box 3-2 Investment and expenditures of 'downstream user' sectors in scope in the EU-27 in 2022

The **cosmetics and personal care** products industry invested over €2 billion in capital (~4% of sales turnover) and had operating expenditures of over €50 billion (~85% of sales turnover).

The **paints, coatings, adhesives, elastomers and printing Inks** industry invested around €2 billion in capital (~4% of sales turnover) and had operating expenditures of around €47 billion (~90% of sales turnover).

The **detergents and cleaning products** industry invested over €1 billion in capital (~5% of sales turnover) and had operating expenditures of over €20 billion (~85% of sales turnover).

The **agrochemical products and applications** industry invested over €350 million in capital (~3% of sales turnover) and had operating expenditures of over €10 billion (~90% of sales turnover).

The **chemical products for textiles and leather** industry invested over €360 million in capital (~4% of sales turnover) and had operating expenditures of under €10 billion (~90% of sales turnover).

3.1.3.3 Trade in the EU-27

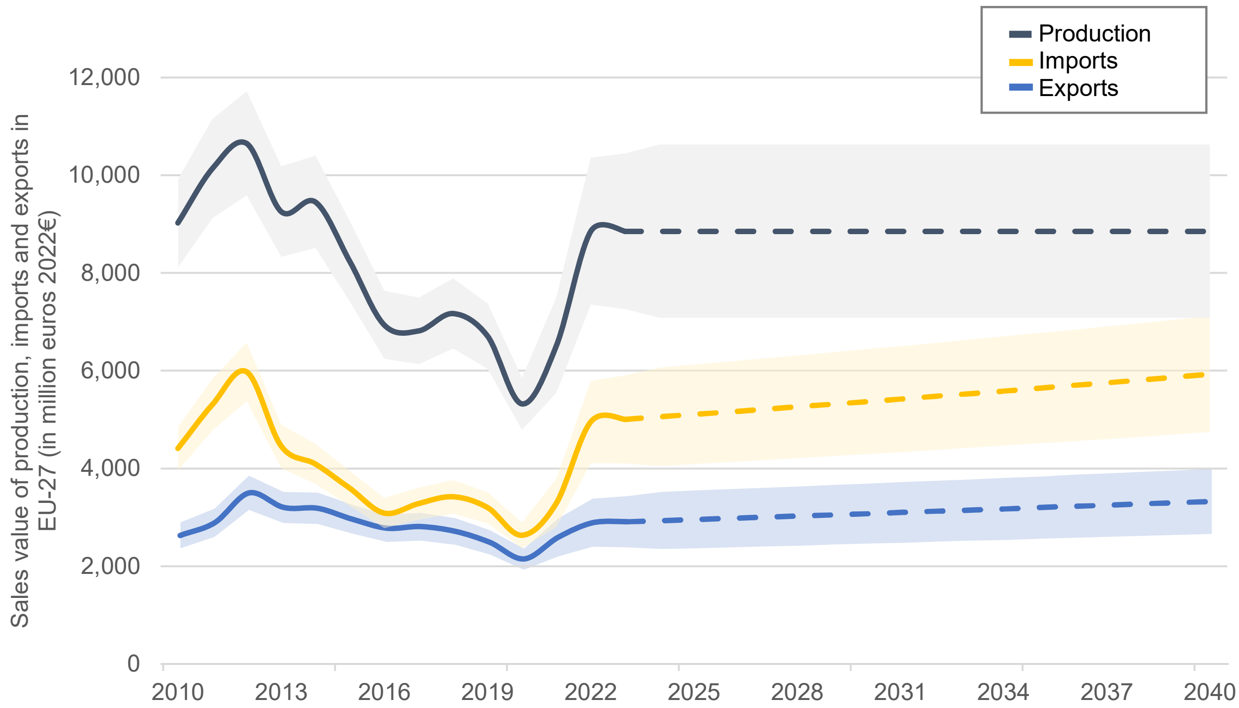
Over the last decade, exports of surfactant products have grown (0.8% per annum or p.a.) slightly slower than imports (1% p.a.). This might reflect, in part, relative increases in the cost of production in the

[33] Input-Output methodologies were employed to produce these estimates. Please see Appendix 1 for more details on the methodology employed.

[34] European Commission (2023) Annual report on European SMEs 2022/2023. Available from: https://op.europa.eu/en/publication-detail/-/publication/12f499c0-461d-11ee-92e3-01aa75ed71a1/language-en

EU-27 and a relative loss in international competitiveness in a globalised market. In terms of scale, 2022 production sales value has been estimated at around €9 billion, whereas imports were around €5 billion, and exports reached a sales value of around €3 billion. The available evidence suggests that, although there has been a relative increase in the reliance on imports of surfactants in the EU-27, the sectoral trade balance might remain stable in the future. Figure 3-9 below presents illustrative estimates of the sales value of production, imports and exports of the surfactants manufacturing industry in the EU-27 and their potential evolution till 2040.

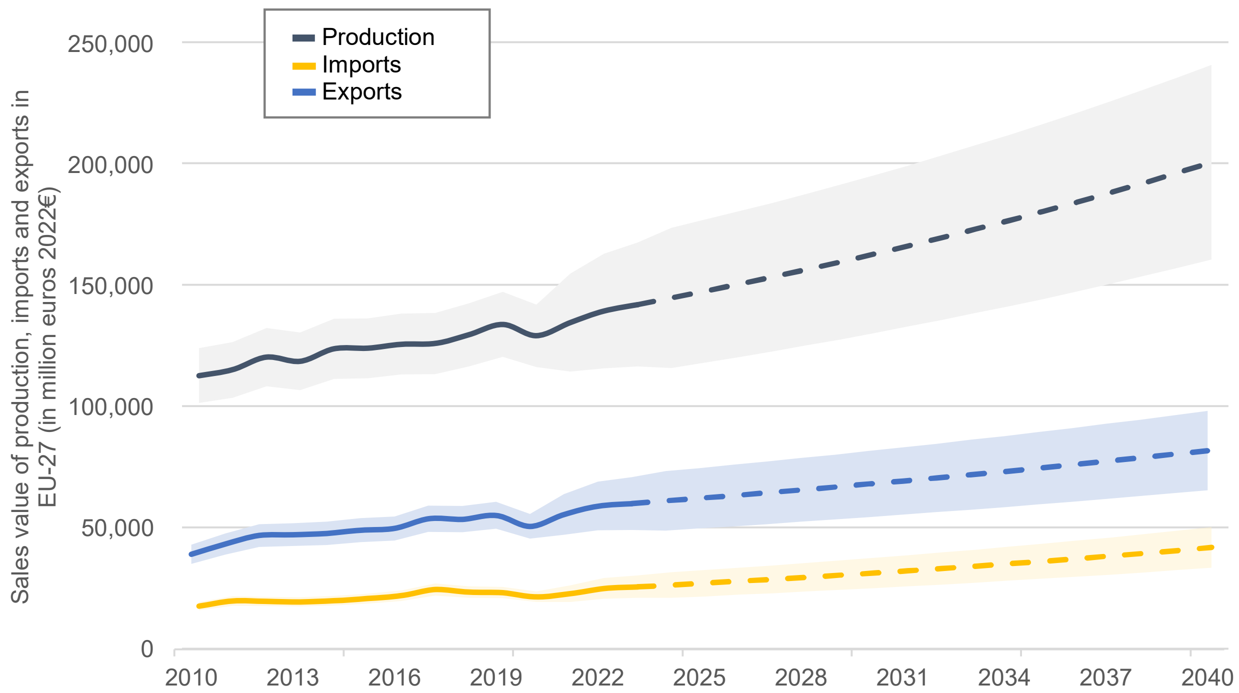
Figure 3-9 Baseline sales value of production, imports and exports of surfactants in the EU-27 (€ million)



Source: Ricardo analysis based on Eurostat data (PRODCOM and SBS) and check and validation from external sources.

Across downstream user industries, however, the trade balance has remained positive in the past decade. Estimates of 'downstream user' exports exceeded imports by more than double in value in 2022, at €59 billion and €25 billion respectively. Across these markets, it is estimated that imports and exports will follow similar trends in the future, with imports growing marginally faster than exports. Figure 3-10 below presents illustrative estimates of the sales value of production, imports and exports of the 'downstream user' industries in the EU-27 and their potential evolution till 2040.

Figure 3-10 Baseline sales value of production, imports and exports of ‘downstream user’ products in the EU-27 (€ million)



Source: Ricardo analysis based on Eurostat data (PRODCOM and SBS) and check and validation from external sources.

The baseline data and forecasts for the trade indicators for each ‘downstream user’ sector are presented in the Box below.

Box 3-3 Baseline investment and expenditures of specific ‘downstream user’ sectors in scope in the EU-27

Cosmetics and personal care products

For the cosmetics and personal care products industry, exports far exceeded imports in value in 2022, at €29 billion and €7 billion respectively. The trade balance is estimated to remain positive in the coming decade, with exports growing slightly faster than imports.

Paints, Coatings, Adhesives, Elastomers and Printing Inks

For the paints, coatings, adhesives, elastomers and printing inks industry, exports exceeded imports in value in 2022, at around €13 billion and €7 billion respectively. The trade balance is estimated to remain positive albeit decreasing in size in the future, with imports growing faster than exports.

Detergents and cleaning products

For the detergents and cleaning products industry, exports exceeded imports by more than double in value in 2022, at over €8 billion and €4 billion respectively. The trade balance is estimated to remain positive in the future, with both imports and exports growing at similar rates.

Agrochemical products and applications

For the agrochemical products and applications industry, exports exceeded imports by more than double in value in 2022, at around €5 billion and €2 billion respectively. The trade balance is estimated to remain positive in the future, with imports and exports continuing to grow at similar rates.

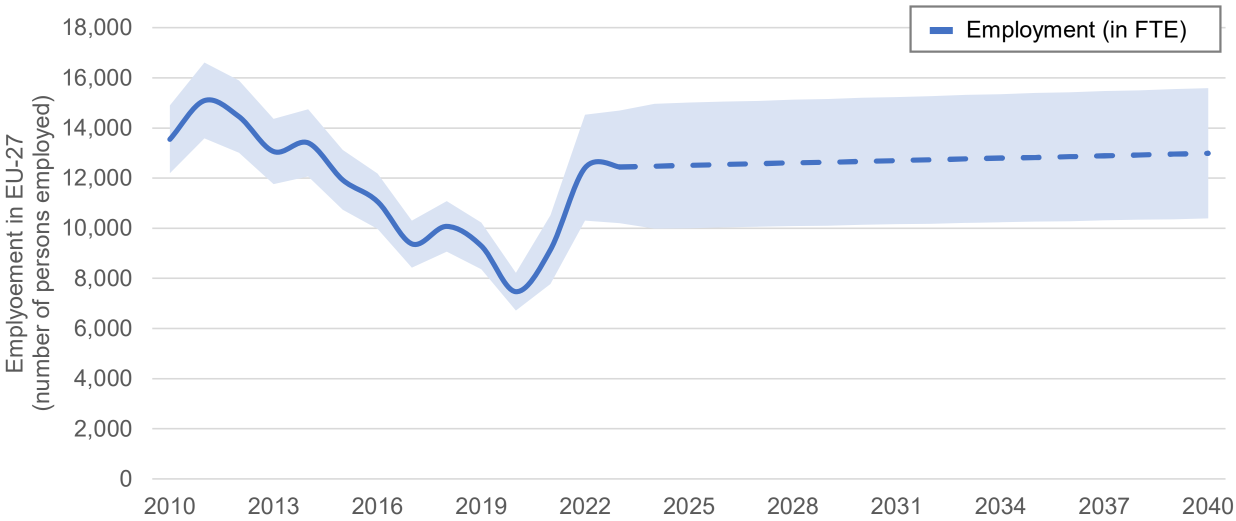
Chemical products for textiles and leather

For the Chemical products for textiles and leather industry, exports and imports were comparable in value in 2022 at around €4 billion, with exports slightly exceeding imports. The trade balance is expected to remain positive, with both imports and exports continuing to grow at similar rates in the future.

3.1.3.4 Employment

The surfactant industry employs more than 12,000 people directly in the EU-27. These professionals are involved in manufacturing, logistics, research and development and a range of other activities required to produce and sell high-quality products to their customers in the EU-27 or abroad. Historically, employment has fluctuated and declined slightly relative to industrial activity. This could be driven by a reduction in labour intensity within the industry, partly due to continued technological advancement and transformation. It is estimated that employment supported by the surfactants industry will remain of a similar scale in the future. Figure 3-11 below presents illustrative estimates of direct employment in the surfactants industry in the EU-27 and the potential evolution till 2040.

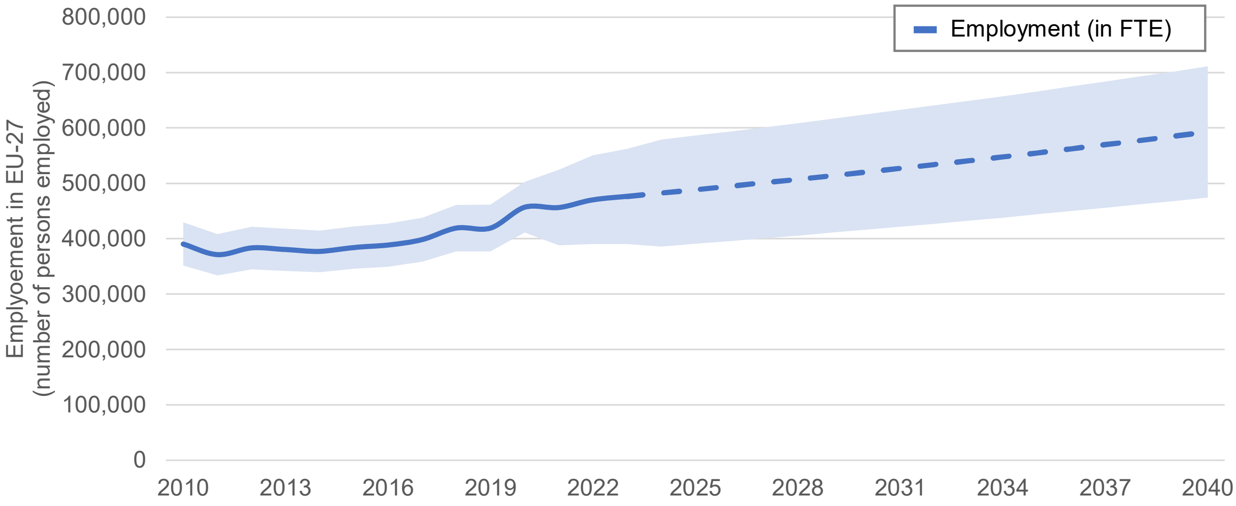
Figure 3-11 Baseline direct employment supported by the surfactants industry in the EU-27 (Number of jobs)



Source: Ricardo analysis based on Eurostat data (PRODCOM and SBS) and check and validation from external sources.

In 2022, 'downstream user' industries directly employed more than 470,000 people in the EU-27, based on the available evidence. Employment across these industries has grown at a real CAGR of around +1.5% in the past decade, enabled by the growth in manufacturing activity observed across these sectors. It is estimated that employment will continue to grow at a CAGR of over +1.0% in the coming decade, which could mean that these downstream industries could directly support more than 590,000 jobs in 2040. Figure 3-12 below presents this forecast.

Figure 3-12 Baseline direct employment supported by the ‘downstream user’ industry in the EU-27 (Number of jobs)



Source: Ricardo analysis based on Eurostat data (PRODCOM and SBS) and check and validation from external sources.

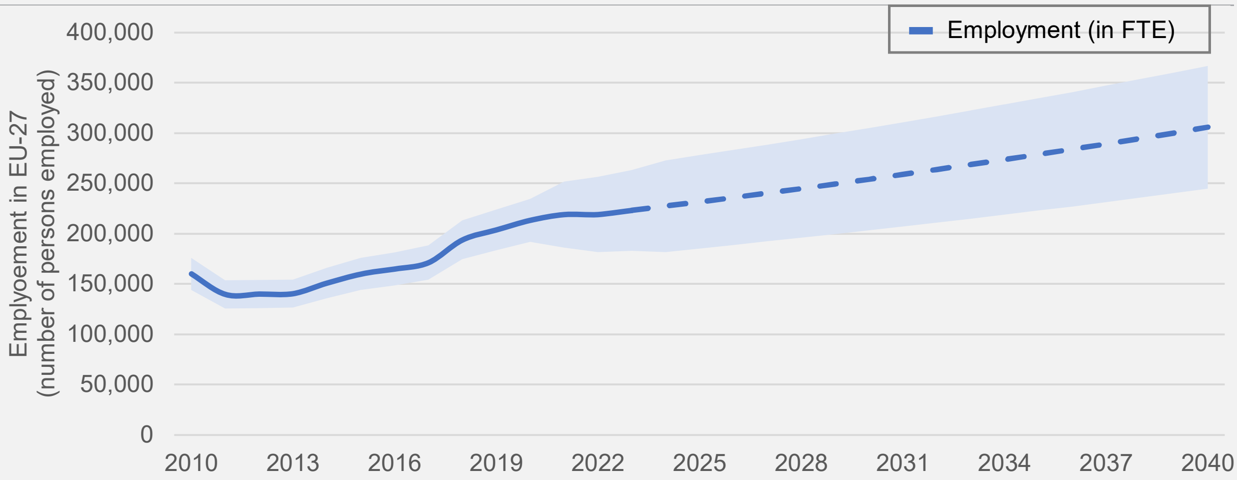
The baseline data and forecasts for direct employment for the specific sectors are presented in the Box below.

Box 3-4 Baseline direct employment supported by specific ‘downstream user’ sectors in scope in the EU-27

Cosmetics and personal care products

In 2022, the cosmetics and personal care products industry directly employed around 220,000 people in the EU-27. Employment in the industry has grown notably over the past decade. It is estimated that employment might continue to grow at a slightly lower rate in the coming decade, thus reaching 300,000 direct jobs in 2040.

Figure 3-13 Baseline direct employment supported by cosmetics and personal care products in the EU-27 (Number of jobs)

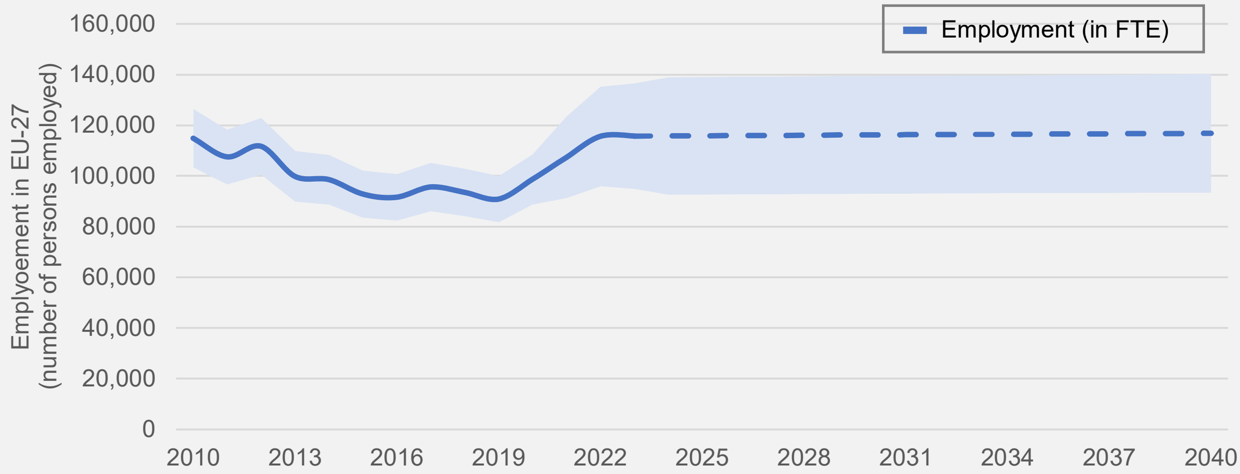


Source: Ricardo analysis based on Eurostat data (PRODCOM and SBS) and check and validation from external sources.

Paints, Coatings, Adhesives, Elastomers and Printing Inks

In 2022, the paints, coatings, adhesives, elastomers and printing inks industry directly employed more than 115,000 people in the EU-27. Employment in the industry has remained stable over the past decade and it is estimated that it might remain so in the coming decade.

Figure 3-14 Baseline direct employment supported by Paints, Coatings, Adhesives, Elastomers and Printing Inks in the EU-27 (Number of jobs)

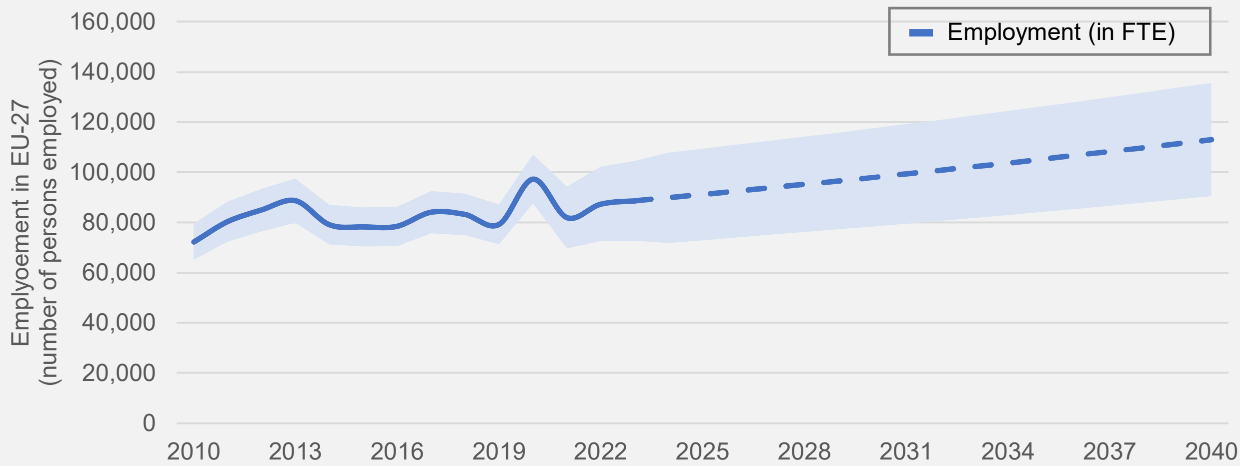


Source: Ricardo analysis based on Eurostat data (PRODCOM and SBS) and check and validation from external sources.

Detergents and cleaning products

In 2022, the detergents and cleaning products industry directly employed more than 85,000 people in the EU-27. Employment in the industry has grown over the past decade and is estimated to continue to grow at a similar rate in the future. As a result, the industry might directly support more than 110,000 jobs in 2040.

Figure 3-15 Baseline direct employment supported by Detergents and cleaning products in the EU-27 (Number of jobs)

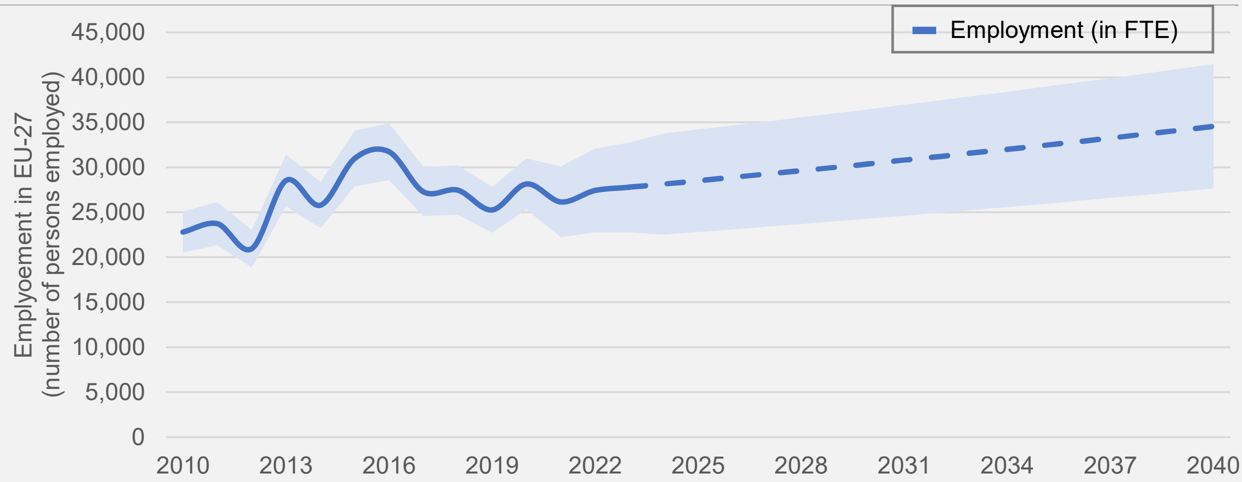


Source: Ricardo analysis based on Eurostat data (PRODCOM and SBS) and check and validation from external sources.

Agrochemical products and applications

In 2022, the agrochemical products and applications industry directly employed more than 27,000 people in the EU-27. Employment in the industry has grown over the past decade and this is estimated to continue in the future. The industry might directly support more than 34,000 jobs in 2040.

Figure 3-16 Baseline direct employment supported by Agrochemical products and applications in the EU-27 (Number of jobs)

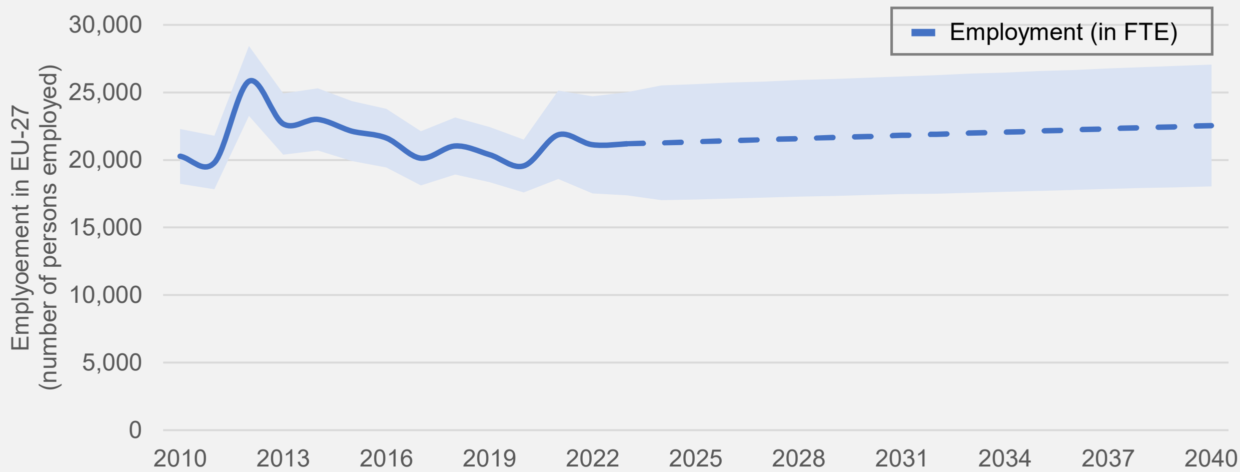


Source: Ricardo analysis based on Eurostat data (PRODCOM and SBS) and check and validation from external sources.

Chemical products for textiles and leather

In 2022, the chemical products for textiles and leather industry directly employed more than 21,000 people in the EU-27. Employment in the industry has remained stable over the past decade and is estimated to remain so in the future.

Figure 3-17 Baseline direct employment supported by Chemical products for textiles and leather in the EU-27 (Number of jobs)



Source: Ricardo analysis based on Eurostat data (PRODCOM and SBS) and check and validation from external sources.

Overall, the surfactants value chain, comprising the surfactants sector and 'downstream user' sectors, employ more than 480,000 people directly in the EU-27. It is also estimated that a similar scale of jobs might be supported indirectly in the EU-27, due to the interconnections with other sectors in the economy (including upstream sectors) and the contributions to the purchasing power of European consumers. Please note that these estimates are based on a subset of the value chain in scope of the assessment.

Finally, these baseline estimates of the economic value chain of surfactants in the EU-27 present the scale and order of magnitude of the markets in scope of this study. They have limitations inherent to any forecasting exercise, exacerbated by the lack of available information. Moreover, these economic sectors are affected by a wide range of international dynamics in a context of accelerated transformation and technological advancement which might not be captured in the baseline assessment; thus, their production pathways could be severely affected in ways that are not easy to foresee at this stage.

Overall, it is concluded that the estimates presented of the size of the EU-27 manufacturing activities, expenditures, trade and employment offer a practical and reasonable counterfactual against which to consider the potential effects of the restriction scenarios under assessment.

3.1.4 Baseline emissions of 1,4-dioxane from surfactant manufacturing and applications and their associated environmental concerns

This section describes the emissions of 1,4-dioxane to the environmental of the surfactants' value chain in the EU-27.

Surfactants with 1,4-dioxane as an impurity can release 1,4-dioxane into the environment, particularly to water compartments such as ground water, surface water and drinking water, during their manufacture and use. This includes[35]:

- Manufacturing and formulation of surfactants and surfactants containing products: Disposal of wastewater containing 1,4-dioxane to wastewater treatment plants.
- Uses and applications of surfactants containing products at industrial sites, by professional workers and by downstream consumer uses: Disposal of products containing surfactants 'down the drain' to wastewater treatment plants.

The treated effluent from wastewater treatment plants can then proceed to surface water and subsequently to groundwater. There is limited information on levels of 1,4-dioxane in surface and ground water in the EU with the data generally focused on Germany and the Netherlands. Reported levels in the literature include:

- Surface water in Germany: levels of 1,4-dioxane in the Rhine between 0.69-1.70 µg/L, below LOQ-4.49 µg/L in the Lippe and 2.00-4.70 µg/L in the Oder[36].
- Surface water in the Netherlands: levels of 1,4-dioxane 0.249 - 1.42 µg/L at Lobith, 0.26 - 0.75 µg/L at Nieuwegein, 0.24 - 0.85µg/L at Nieuwersluis and 0.098 - 0.4 µg/L at water Andijk[37].
- Levels up to 3537 ng/L 1,4-dioxane in surface water, 1467 ng/L in bank filtrate, 1000 ng/L in rainwater and 770 ng/L in drinking water are reported in a report by UBA[38].

The removal of 1,4-dioxane from water compartments can be difficult and as well as being energy intensive. Its removal in wastewater treatment plants can also be limited, this is discussed further in Section 4.2.3[39].

The concerns of 1,4-dioxane in the environment are related to its persistence and mobility in water compartments, given that the substance has a preference for the aqueous phase when it is in the environment[39]. 1,4-dioxane has an overall persistence (P_{oc}) of 1,771 days, which has been calculated using the OECD tool for Long Range Transport Potential[39]. The substance has also been classed as mobile in the environment based on its water solubility, partition coefficient (log K_{ow}) and its detection in groundwater, surface water and drinking water in various studies.

The substance is not bioaccumulative, based on the available literature. Concerning its ecotoxicity, there have been studies assessing the toxicity of 1,4-dioxane in fish, crustaceans, and algae at trophic levels with low toxicity observed in these studies[40]. The ECHA Annex XV report also concludes that chronic/acute effects are only observed at high concentrations (>100 mg/L) [39]. Please note that 1,4-dioxane is considered toxic based on its carcinogenic classification for human health; however, the assessment of potential human health effects is out of scope of this SEA study.

[35] Doherty A-C, Lee C-S, Meng Q, Sakano Y, Noble AE, Grant KA, Esposito A, Gobler CK and Venkatesan AK (2023). Contribution of household and personal care products to 1,4-dioxane contamination of drinking water. Current Opinion in Environmental Science & Health, 31:100414.

[36] Karges U et al (2022). Implementation of initial emission mitigation measures for 1,4-dioxane in Germany: Are they taking effect? Science of the Total Environment, 806, 1050701. Data is reported in the supplementary information.

[37] RIWA (2021) Annual Report (2020). The Rhine. Available from: https://www.riwa-rijn.org/wp-content/uploads/2021/10/RIWA-2021-EN-Anual-Report-2020-The-Rhine.pdf

[38] Umwelt Bundesamt (2023). Prioritised PMT/vPvM substance in the REACH registration database. Available from: https://www.umweltbundesamt.de/sites/default/files/medien/11850/publikationen/21_2023_texte_pmt_vpvm_substances_reach_v23032023.pdf

[39] ECHA (2021). Proposal for Identification of a Substance of Very High Concern on the Basis of the Criteria set out in REACH Article 57 – 1,4-dioxane. Available at: https://echa.europa.eu/documents/10162/435f5245-3bad-5ff5-65f3-0b279c9b6847

[40] United States Environmental Protection Agency (2024). ECOTOX Knowledgebase. Available from: https://cfpub.epa.gov/ecotox/search.cfm

The environmental impact of the surfactants value chain in the EU-27 is estimated with regards to the environmental emissions of 1,4-dioxane from EO-based surfactants. Estimated 'baseline emissions' of 1,4-dioxane across the surfactants' value chain for manufacturers and the five downstream sectors in scope of this SEA are presented in Table 3-4 overleaf. Low, medium and high estimates have been developed, based on the uncertainties concerning the levels of 1,4-dioxane in surfactants.

Table 3-4 Overview of baseline environmental emissions for manufacturers

Indicator	Emissions of 1,4-dioxane (tpa)		
	Low	**Medium**	**High**
Baseline emissions (manufacturers of surfactants)	8.5	19.5	35
Baseline emissions (downstream user sectors in scope)	5.5	13	24

Source: Ricardo analysis based on stakeholder responses, wastewater data from the UBA survey study and tonnage data from CESIO.

It is worth noting that there is no data publicly available on emissions of 1,4-dioxane to the environment (i.e. tonnes per annum (tpa)) for the EU-27). The emissions for manufacturers have been based on the data collected from the UBA survey study[41] on the volume of cubic meters of treated wastewater produced and levels of 1,4-dioxane in surfactants collected from the SEA survey. The emissions for the downstream uses (indirect emissions) have been estimated from the levels of 1,4-dioxane in downstream products from the survey responses and CESIO 2021 tonnage data, based on a worst-case scenario of 100% of the surfactant going down the drain. These estimates are used as basis for estimating the potential scale of emissions reductions in the restriction scenarios.

There are also other sources of 1,4-dioxane emissions to the environment in addition to EO surfactants, also resulting as a by-product of the manufacturing process[42,43]. In the EU, there is also limited data on levels of 1,4-dioxane releases to water from other sources in the 2002 EU RAR for 1,4-dioxane[44]. These other sources and volumes are not considered within this assessment.

3.1.5 Current regulation

1,4-dioxane is registered under EU-REACH in the ≥ 1 000 to < 10 000 tonnes per annum tonnage band.[45] Within the REACH registration dossier, 1,4-dioxane is used in formulation or re-packaging, in manufacturing, in articles, at industrial sites and by professional workers with widespread uses.

For the water compartment, 1,4-dioxane is under consideration as a Persistence, Mobility, Toxic (PMT) substance[46]. For human health, 1,4-dioxane is listed in Annex XV of the CLP Regulation and is classified as a Carcinogenic 1B (Carc. 1B) substance (H350)[47].

Under the Chemicals Agent Directive (CAD) (Directive 98/24/EC), 1,4-dioxane has an indicative Occupational Exposure Limit (OEL) of 73 mg/m^3 (20 ppm)[48]. ECHA have recommended an 8-hour Time Weighed Average (TWA) OEL of 6 ppm (22 mg/m^3), Short Term Exposure Limit (STEL) of 20 ppm (73 mg/m^3), and a Biological

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[41] Ricardo (2024). CESIO response to the UBA questionnaire. Draft report for CESIO.

[42] Chemical and Engineering News (2020). 1,4-Dioxane: Another forever chemical plagues drinking-water utilities. Available from: https://cen.acs.org/environment/pollution/14-Dioxane-Another-forever-chemical/98/i43

[43] Čolnik et al. (2021). Sub- and supercritical water for chemical recycling of polyethylene terephthalate waste. Chemical Engineering Science, 233, 116389.

[44] European Chemicals Bureau (2002). European Union Risk Assessment Report 1,4-dioxane. Available from: https://echa.europa.eu/documents/10162/a4e83a6a-c421-4243-a8df-3e84893082aa

[45] ECHA (n.d.). 1,4-dioxane Substance Infocard. Available from: https://echa.europa.eu/substance-information/-/substanceinfo/100.004.239

[46] ECHA (n.d.). PBT assessment list – 1,4-dioxane. Available from: https://echa.europa.eu/pbt/-/dislist/details/0b0236e18_3691f6e

[47] ECHA (n.d.. Summary of Classification and Labelling – 1,4-dioxane. Available from: https://echa.europa.eu/information-on-chemicals/cl-inventory-database/-/discli/details/76034

[48] Commission Directive 2009/161/EU of 17 December 2009 establishing a third list of indicative occupational exposure limit values in implementation of Council Directive 98/24/EC and amending Commission Directive 2009/39/EC. Available from: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009L0161

Limit Value (BLV) of 120 mg 2-hydroxyethoxyacetic acid/g creatinine under the Carcinogens, Mutagens or Reprotoxic substances at work Directive (CMRD) (Directive 2004/37/EC)[49].

1,4-dioxane is also listed in Annex II of the Cosmetic Products Regulation (Regulation (EC) No 1223/2009) and its use is prohibited in cosmetic products[50]. Residual concentrations of below 10 ppm in cosmetic products have been considered to be safe for consumers by the Scientific Committee on Consumer Safety (SCCS)[51].

3.2 PROPOSED RESTRICTION SCENARIOS

The call for evidence published on the 19th of April 2023 by the German REACH competent authority covered a restriction on the manufacture and use of surfactants which contain more than 1 mg of 1,4-dioxane in 1 kg of surfactant active matter (1 ppm of 1,4-dioxane) and which is further described in the Box below[52]. However, the expected submission of the proposed restriction has since been delayed until October 2025[53].

Two potential restriction scenarios provided by CESIO have been assessed in this SEA study:

- Restriction Scenario (RS) 1: Restriction of manufacturing and/or placing on the EU-27 market, surfactants with **1 ppm or more (≥1 ppm)** of 1,4-dioxane as an impurity in active matter.
- RS2: Restriction of manufacturing and/or placing on the EU-27 market, surfactants with **10 ppm or more (≥10 ppm)** of 1,4-dioxane as an impurity in active matter[54].

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 derogations that may be carried forward. Additional restriction conditions such as wastewater limit values are not considered in this assessment. However, the assessment carried out and its outputs are highly dependent on these assumptions and, therefore, reflect the same level of uncertainty.

Box 3-3 Preliminary draft entry text for the proposed restriction concerning the manufacturing and use of surfactants which contain 1,4-dioxane and the conditions of restriction[55]

"*1. Organic, surface-active substances containing 1,4-dioxane shall not be manufactured.2. Shall not be placed on the market or used in organic, surface-active substances ("surfactants") as a constituent in a concentration of above 0.0001% by weight (1 ppm).*

3. Shall not be placed on the market or used in mixtures and articles containing surfactants with 1,4-dioxane as a constituent.

4. By way of derogation to paragraph 1, the manufacture of surfactants containing 1,4-dioxane shall be allowed, if it is ensured that the process waste waters and the waste water produced during maintenance process are free of 1,4-dioxane after treatment"

5. By way of derogation to paragraph 2 and 3, the placing on the market of mixtures and articles containing surfactants with 1,4-dioxane as a constituent shall be allowed, if the surfactants are used solely in closed systems and it is ensured that the process waste waters and the waste water produced during maintenance processes are free of 1,4-dioxane after treatment."

[49] Directive 2004/37/EC of the European Parliament and of the Council of 29 April 2004 on the protection of workers from the risks related to exposure to carcinogens, mutagens or reprotoxic substances at work. Available from: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02004L0037-20240408

[50] Regulation (EC) No 1223/2009 of the European Parliament and of the Council of 30 November 2009 on cosmetic products. Available from: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02009R1223-20240424&qid=1720769511604

[51] SCCS (2015). Scientific Opinion on The Report of the ICCR Working Group: Considerations on Acceptable Trace Level of 1,4-Dioxane in Cosmetic Products. Available from: https://ec.europa.eu/health/scientific_committees/consumer_safety/docs/sccs_o_194.pdf

[52] ECHA (2023). Call for Evidence and Information on 1,4-dioxane as well as Substances and Mixtures Containing 1,4-dioxane as a Constituent or an Impurity. Available at: https://echa.europa.eu/documents/10162/5d05d8e1-27bb-74c5-b102-d5b903aa7e13

[53] ECHA (2023). Registry of restriction intentions until outcome – 1,4-dioxane. Available from: https://echa.europa.eu/registry-of-restriction-intentions/-/dislist/details/0b0236e18609e1d9

[54] This restriction scenario was added, following a suggestion from BAuA dated 26th September 2023.

[55] CESIO (2023). BAUA Preliminary draft entry text for the proposed restriction of the manufacture and use of surfactants containing 1,4-dioxane response to BAuA.

4. ANALYSIS OF IMPACTS

This section contains a presentation of the economic and environmental impacts across the shortlisted impact categories and concludes on the overall costs and benefits associated with each of the two restriction scenarios under consideration.

A brief description of the methodology has been provided in Section 2, and a more detailed outline of the analytical methods and detailed outputs used in the SEA could be found in the Appendices.

4.1 ECONOMIC IMPACTS

This section presents the assessment of economic impacts of the two restriction scenarios under assessment, structured in five subsections as follows:

- **Industrial activity:** estimated impacts of the two restriction scenarios on the size, functioning and resilience of the industry.
- **Innovation and research:** investigation of the potential alternatives to the use of surfactants containing 1,4-dioxane as an impurity, including availability, technical feasibility, and performance of alternatives.
- **Global competitiveness and trade:** estimated impacts on industry's competitiveness and a discussion of the implications that the REACH restriction might have on international trade dynamics.
- **Other (wider) economic impacts:** estimated employment and consumer impacts, including impacts on product availability, quality, performance and accessibility of alternatives.
- **Overall economic impacts in the EU-27:** estimated impacts on the overall EU-27 economy, quantitatively via potential implications on the Gross Domestic Product of the EU-27 and qualitatively across the shortlisted impact categories.

The analysis and results presented in this Section are based on publicly available evidence and literature, including Eurostat datasets such as PRODCOM and SBS and the online survey and follow-up interviews of companies manufacturing or importing surfactants and 'downstream user' businesses across the sectors in scope. A detailed consultation synopsis is presented in the Annexes. The evidence presented in the following sections is thus based on analysis of the evidence from these sources. Please note that when ranges are presented, the 'medium' estimate is generally based on the weighted or simple averages of the evidence collected, and the 25% and 75% percentile provide the basis for the 'low' and 'high' estimates.

4.1.1 Industrial activity

In 2022, the scale of manufacturing activity in the EU-27 across the suppliers of surfactants and downstream industries in scope has been estimated to be around €170 billion (see Section 3.1.3), which comprises around €10 billion of sales from upstream manufacturing activity and around €160 billion of sales from 'downstream user' manufacturing activity in the EU-27. This section summarises the assessment of impacts of adopting the two restriction scenarios in three key steps.

- **Step 1: 'the affected portfolio of products' is estimated across the restriction scenarios.** Conceptually, under RS1, any manufacture of surfactants with 1 ppm or more of 1,4-dioxane as an impurity in active matter and/or any 'downstream user' companies that rely on these products would be affected. Under RS2, any manufacture of surfactants with 10 ppm or more of 1,4-dioxane as an impurity in active matter and/or any 'downstream user' companies that rely on these products would be affected.
- **Step 2: the business response is characterised, which includes the introduction of potential alternatives and substitutes and the costs that might be incurred as a result**. Illustratively, alternative processes to produce surfactants might include technologies that can reduce the presence of 1,4-dioxane as an impurity in active matter to below 1ppm or 10ppm. Moreover, applications of surfactants containing 1,4-dioxane as an impurity across 'downstream user' sectors could be substituted by other substances and/or materials that contain no or low 1,4-dioxane content. A literature review was conducted, and companies were consulted to estimate the potential scale of capital and operating costs of 'substitution'.

- **Step 3: impacts on industrial activity in the EU-27 were estimated.** Having identified the proportion of surfactant manufacturing and downstream activity that could be affected under each of the restriction scenarios (step 1) and characterised the potential business response to reduce these impacts (step 2), the potential effects on the scale of industrial activity in the EU-27 were considered. This could include shifts in manufacturing of upstream activity to other regions in which substitution may be economically viable and/or withdrawing products and even complete supply chains from the market. The scale of these impacts has also been estimated by considering the available literature and input from companies within the surfactants industry as well as 'downstream user' sectors.

The analysis across each of these steps and, thus, the assessment of impact on the size, functioning and sustainability of the EU-27 industry are considered in the following subsections.

4.1.1.1 The affected portfolio of surfactants and downstream products

Businesses were consulted (N=85)[56] about the products they manufactured and/or imported in the EU-27 across the surfactants industry (N=40) as well as a diverse selection of 'downstream user' sectors (N=45), including '*Cosmetics and personal care products*', '*Paints, Coatings, Adhesives, Elastomers and Printing Inks*', '*Detergents and cleaning products*', '*Agrochemical products and applications*' and '*Chemical products for textiles and leather*'. The breakdown by sectors is given in Appendix 6.

The restriction scenarios under consideration pose a significant challenge to the EU-27 manufacturers, and/or importers of surfactants. All manufacturers and importers of surfactants who participated in the stakeholder consultation said that surfactants containing 1,4-dioxane as an impurity are among the surfactants that they either use or produce, and the majority of them said they were aware of the levels of 1,4-dioxane in their surfactants (see Appendix 6 for the consultation synopsis). Based on their responses, the manufacturing and importing activity pertaining to the surfactants market could be potentially affected under any restriction scenario. The analysis of evidence collected through the industry consultation suggests that 70% (50-100%) of the sales from manufacturers and importers of surfactants could be affected by the restriction under RS1, and 40% (15-50%) under RS2. These estimates are summarised in the Table below.

Table 4-1 Percentage of sales turnover of the surfactant industry in the EU-27 which could be affected under each restriction scenario (medium (low-high) %)

Indicator	RS1	RS2
Percentage of the sales turnover of the surfactant industry which could be **potentially affected**	**70%** (50%-100%)	**40%** (15%-50%)

Source: Ricardo analysis based on evidence collected from business stakeholders (N=36).

The 'downstream user' sectors that rely, in some way, on surfactants in their manufacturing processes and/or for their product components would necessarily be affected in some way. It is, however, uncertain the extent to which products manufactured and/or imported by companies across these sectors in scope contain and/or require surfactants with levels of active matter subject to restriction. Thus, 'downstream user' companies were also consulted. The surfactants impacted by the restriction scenarios and their respective key sectors of use are presented in Appendix 4.

Overall, the majority of 'downstream user' companies who participated in the survey were aware of the presence of 1,4-dioxane as an impurity in the surfactant products used by them during their manufacturing activity or contained in the products they place on the market, albeit awareness of the specific levels of 1,4-dioxane associated with these products varied across sectors. Therefore, a combination of quantitative (online survey responses) and qualitative insights (follow-up interviews, expert input) were collected to add to further understanding and develop appropriate assumptions.

[56] N is short for the sample size of the businesses that participated in the online survey and follow-up interviews conducted as part of this Study. A total of 85 businesses submitted evidence to this Study. More organisations participated; however, their submissions were insufficiently complete to include as part of the assessment. Of these 85, 40 were businesses or organisations which belonged to the surfactant industry and 45 were 'downstream users'. A more detailed consultation synopsis can be found in Appendix 6.

Estimates of the levels of 1,4-dioxane in the downstream user products and, thus, the resulting 'affected portfolio' of products for the individual and 'aggregate' downstream user sectors are presented in the Box below.

Box 4-1 Estimation of the 'affected portfolio' of specific 'downstream user' sectors in scope in the EU-27

The participants to the stakeholder consultation have provided us with evidence of the levels of 1,4-dioxane associated with their products, based on which we have developed working assumptions about the proportion of their downstream product sales by level 1,4-dioxane as presented in the Table below.

Table 4-2 Average proportion of 'downstream user' sales in the EU-27 associated with surfactants by levels of 1,4-dioxane (% of sales turnover)

'Downstream user' industry	Proportion of 'downstream user' sales that contain and/or require surfactants with levels of 1,4-dioxane…			
	No 1,4-dioxane[57] (0 ppm)	>0 - <1 ppm	≥1 - < 10 ppm	≥10 ppm
Detergents and cleaning products	~10%	~25%	~15%	~50%
Cosmetics and personal care products	~5%	~35%	~30%	~30%
Paints, Coatings, Adhesives, Elastomers, and Printing Inks	~25%	~5%	~30%	~40%
Chemical products for the textiles and leather sector	~20%	~10%	~25%	~45%
Agrochemical products and applications	~5%	~7%	~25%	~63%
Average across the selected downstream sectors	**~15%**	**~20%**	**~25%**	**~40%**

Source: Ricardo analysis based on evidence collected from business stakeholders (N=33), interviews and expert input.

This evidence is uncertain. Some sectors in particular (e.g., the agrochemical products and applications sector) were unaware of the level of 1,4-dioxane in the surfactant products used by them and could not quantify them in their responses to the stakeholder consultation. Qualitative insights collected through interviews and expert input were used to develop appropriate assumptions for each sector to the extent that was possible. Overall, we have concluded that the available evidence was sufficient to use as a basis for the analysis of the potential scale of impact of the restriction scenarios. However, it is not possible to conclude on the level of statistical representativeness against the sectors in scope, and it is likely affected by self-selection bias.

The 'potentially affected' portfolio of products across downstream user markets were thus estimated based on the estimated breakdown of the portfolio of products by the levels of 1,4-dioxane. In particular, **the activities that contain and/or require surfactants with ≥1 ppm (RS1) or ≥10 ppm (RS2) could, therefore, be potentially affected by these restriction scenarios**. The resulting estimates are presented in the Table below.

[57] This refers to the proportion of 'downstream user' sales from surfactants which do not contain any 1,4-dioxane.

Table 4-3 Percentage of sales turnover of the 'downstream user' industries in the EU-27 which could be affected under each restriction scenario (medium (low-high) %)[58]

'Downstream user' industry	Percentage of the 'downstream user' sales turnover which could be potentially affected under…	
	RS1	RS2
Detergents and cleaning products	**65%** (45%-95%)	**50%** (10%-85%)
Cosmetics and personal care products	**60%** (30%-90%)	**30%** (0%-60%)
Paints, Coatings, Adhesives, Elastomers, and Printing Inks	**70%** (65%-90%)	**40%** (10%-55%)
Chemical products for the textiles and leather sector	**70%** (50%-85%)	**45%** (35%-50%)
Agrochemical products and applications	**88%** (75%-100%)	**63%** (50%-75%)
Average across the selected downstream sectors	**65%** (45%-90%)	**40%** (10%-65%)

Source: Ricardo analysis based on evidence collected from business stakeholders (N=33), interviews and expert input.

Overall, the potentially affected portfolio for the cosmetics and personal care products sector was below the average for the downstream user sector as a whole, whereas all other sectors in scope had affected portfolios greater than or equal to the average. Under RS1, the sales that could be potentially affected varied from 60% (30-90%) for the cosmetics and personal care products sector, 65% (45-95%) for the detergents and cleaning products sector, 70% (50-85%) for the chemical products for textiles and leather sector, 70% (65-90%) for the paints, coatings, adhesives, elastomers and printing inks sector to 88% (75-100%) for the agrochemical products and applications sector. Under RS2, the industry sales in the EU-27 that could be potentially affected would be lower, ranging from 30% (0-60%) for the cosmetics and personal care products sector, 40% (10-55%) for the paints, coatings, adhesives, elastomers and printing inks sector, 45% (35-50%) for the chemical products for textiles and leather sector, 50% (10-85%) for the detergents and cleaning products sector and 63% (50-75%) for the agrochemical products and applications sector.

On average, around 85% of the sales turnover attributable to the 'downstream user' sectors in scope in the EU-27 was estimated to depend, in some way, on surfactants with active matter containing some 1,4-dioxane in the surfactant active matter. More specifically, it has been estimated that **65% (45-90%) of all 'downstream user' sales in the EU-27 might contain and/or require surfactants with ≥1 ppm of 1,4-dioxane and thus could be potentially affected under RS1,** and **40% (10-65%) of total downstream user sales might contain and/or require surfactants with ≥10 ppm of 1,4-dioxane under RS2.** These estimates are also presented in Table 4-4 below.

Table 4-4 Percentage of sales turnover of the 'downstream user' industries in the EU-27 which could be affected under each restriction scenario (medium (low-high) %)

Indicator	RS1	RS2
Average percentage of the sales turnover which could be **potentially affected across the downstream sectors**	**65%** (45%-90%)	**40%** (10%-65%)

Source: Ricardo analysis based on evidence collected from business stakeholders (N=33), interviews and expert input.

[58] Please note that whilst there are wide variations across the survey respondents, the central estimates of the affected portfolio appear reasonable and potentially conservative, given that respondents representing ~85% of the turnover of all survey participants reported that ~80% of their portfolio potentially contained and/or required surfactants with positive levels of 1,4-dioxane.

There is a wide range of applications of surfactants across 'downstream user' sectors, including critical applications with limited or no viable substitutes. Thus, the restriction scenarios might have further implications across downstream markets in the EU, including by raising the costs of doing business, negatively impacting international competitiveness, and reducing the availability of high-quality products and consumer choice. Businesses will thus take any action they can to mitigate any potential disruptions of their activity in the EU-27. These potential impacts are considered in the following subsection.

4.1.1.2 The business response and costs

Upon the introduction of any of the restriction scenarios under consideration, **companies manufacturing, importing and/or using surfactants with levels of 1,4-dioxane subject to restriction might respond by: i) making adjustments to their products and/or operations in the EU-27 if these are technically and economically viable, and/or ii) withdraw from the EU-27 market** (see Section 4.1.1.3). A literature review was conducted, and business were asked to explore any viable adjustments they could make to the baseline substances, materials and products along the supply chain and/or introduce any viable alternatives or substitutes they have identified and/or developed so far.

The findings suggest that some viable alternatives and substitutes exist, especially under RS2 and, to a lower extent, under the more restrictive scenario RS1, albeit this is uncertain. Removal or 'stripping' technologies that are available could, at a cost (e.g., CAPEX on technological assets, higher energy requirements, loss of productivity due to longer cycle times, etc.), reduce the level of 1,4-dioxane as an impurity either below 10 ppm or 1 ppm as required under the restriction scenarios, albeit this may not always be technically or economically feasible and effective. However, the resulting materials and products, both up- and down-stream, might become more expensive, especially compared to the baseline. Section 4.1.2 also provides additional insights and depth on the opportunities that innovation and research might offer companies if the restriction scenarios were adopted, covering the availability now and/or in the future, viability and performance of potential 'alternative' or 'substitute' options.

Any effects on performance can also have environmental implications explored in Section 4.2, such as shortening useful product/asset lives and thus needing more frequent component or product replacements, lowering levels of energy efficiency and thus increasing energy use and potentially additional greenhouse gas emissions, and others.

The scale of these viable alternatives and substitutes also remains uncertain. It is difficult to estimate the proportion of the affected portfolio of baseline products under each restriction scenario that could be adjusted and/or replaced with viable alternatives, especially given the wide range of applications with different technical and economic requirements. Upstream and 'downstream user' companies consulted as part of this Study were tasked with reviewing their product portfolios and establishing the proportions which could be adjusted and/or substituted under each of the restriction scenarios.

Businesses manufacturing surfactants in the EU-27 might be able to transform part of their production under RS1 and even more under RS2. Some survey participants reported they would be able to substitute and/or adjust at least part of their operations in the EU-27 under RS1 and RS2, thereby enabling them to remain operative in the global market despite the additional costs incurred as a result of the restriction scenarios (e.g., through the investment in removal technologies to reduce the level of 1,4-dioxane etc).

Businesses have provided feedback suggesting that it would be more feasible, technically and economically, to achieve a 1,4-dioxane concentration level of less than 10 ppm using existing removal technologies and/or adjusting the surfactant products. However, reducing the level of 1,4-dioxane to less than 1 ppm would be challenging and have uncertain technical and economic viability, requiring additional time and/or expenditure.

These insights culminated in the development of evidence-based assumptions of the proportions of the 'potentially affected portfolio of products' that could be adjusted (e.g., using the same surfactants with reduced 1,4-dioxane levels) and/or substituted with existing and similarly performing alternatives under each restriction scenario. Based on surfactant manufacturer respondents, the primary business response to both restriction scenarios would be in the form of adjustments, and the potential for adjusting baseline products (e.g., through the use of stripping technologies) is higher under RS2 than under RS1. Respondents highlighted that there is much lower potential for them to substitute any of the affected products with complete alternatives that can meet the 1,4-dioxane impurity thresholds under the restriction scenarios. These estimates for the surfactant manufacturers are presented in Table 4-5.

Table 4-5 Estimated level of adjustment (e.g., using the same surfactants with reduced 1,4-dioxane levels) and/or substitution by surfactant manufacturers in each restriction scenario (medium (low-high) %)

Indicator	RS1	RS2
Percentage of the affected portfolio of surfactants that could be **adjusted** (e.g., using the same surfactants with reduced 1,4-dioxane levels), in sales turnover terms.	**20%** (0%-50%)	**60%** (45%-80%)
Percentage of the affected portfolio of surfactants that could be **substituted with alternatives**, in sales turnover terms.	**5%** (0%-10%)	**10%** (5%-15%)
Percentage of the affected portfolio of surfactants that could be **adjusted and/or substituted with alternatives**, in sales turnover terms.	**25%** (0%-60%)	**70%** (50%-95%)

Source: Ricardo analysis based on evidence collected from business stakeholders (N=31).

This means that, on average, 25% (0-60%) of the affected sales turnover of the surfactants industry in the EU-27 could be transformed i.e., potentially adjusted and/or substituted with similarly performing alternatives under RS1, and 70% (50-95%) under RS2, subject to final customer acceptance. As highlighted in the table, this would comprise:

- The potential for adjustments (e.g., stripping) of 20% (0-50%) and 60% (45-80%) of the potentially affected baseline product portfolio (in terms of sales turnover) under RS1 and RS2 respectively.
- The potential for complete substitution with similarly performing available alternatives of 5% (0-10%) and 10% (5-15%) of the potentially affected baseline product portfolio (in terms of sales turnover) under RS1 and RS2 respectively.

The requirements set under RS1 could also affect 'downstream user' sectors in which: i) surfactant applications are critical, and ii) do not have any technically and economically viable alternatives.

Thus, 'downstream user' companies that participated in the consultation were also asked whether they were aware of 'adjusted' or 'substitute' products that they could draw on to adjust and/or replace their baseline manufacturing and/or importing activities in the EU-27.

Overall, **businesses in the 'downstream user' sectors in scope might also be able to adjust their products or replace them with potential alternatives containing lower levels of 1,4-dioxane impurities**, albeit there was uncertainty regarding the technical viability and effectiveness of these substitutes and adjusted products across some sectors (e.g., paints). Estimates of the potential substitution and/or adjustments for the downstream sectors in scope are presented in the Box below.

Box 4-2 Estimation of the potential downstream adjustment (e.g., using the same surfactants with reduced 1,4-dioxane levels) and/or substitution for specific downstream sectors in scope in the EU-27

The potential level of adjustments and/or substitution in the downstream markets in scope was estimated under each Restriction Scenario, by drawing on consultation responses, expert input and follow-up interviews with selected 'downstream user' companies and upstream evidence. These estimates are presented in Table 4-6 below.

Table 4-6 Estimated level of adjustment and/or substitution for 'downstream user' sectors in each restriction scenario (medium (low-high) %)

'Downstream user' industry	Percentage of the affected portfolio of industry that could be adjusted and/or substituted with alternatives, in sales turnover terms under…	
	RS1	RS2
Detergents and cleaning products	**60%** (5%-100%)	**90%** (60%-100%)

Cosmetics and personal care products	**85%** (55%-100%)	**95%** (85%-100%)
Paints, Coatings, Adhesives, Elastomers, and Printing Inks	**60%** (15%-90%)	**75%** (60%-95%)
Chemical products for the textiles and leather sector	**25%** (15%-65%)	**45%** (25%-65%)
Agrochemical products and applications	**60%** (25%-100%)	**90%** (60%-100%)
Average across the selected downstream sectors	**65%** (30%-100%)	**90%** (65%-100%)

Source: Ricardo analysis based on evidence collected from business stakeholders (N=38), follow-up interviews and expert input.

Under both RS1 and RS2, the 'cosmetics and personal care products' industry is estimated to be able to adjust and/or substitute a higher-than-average proportion of their affected portfolio, whereas the 'chemical products for the textiles and leather' sector is estimated to be able to adjust and/or substitute a lower-than-average proportion of their affected portfolio. Sectoral experts suggest that this can be explained by the many technical applications in this sector, which require specialty chemicals that are tailor-made and need specific types of surfactants that cannot easily be replaced. Estimates for all other 'downstream user' sectors in scope are comparable to the average.

On average, 65% (30-100%) of the baseline affected production activities of the 'downstream user' sectors in the EU-27 could be potentially transformed i.e., adjusted (e.g., using the same surfactants with reduced 1,4-dioxane levels) and/or substituted with similarly performing alternatives under RS1 and 90% (65-100%) under RS2. The levels of downstream substitution and/or adjustment are estimated to be higher under RS2 than under RS1, which is the more restrictive scenario. These estimates are presented in Table 4-7 below.

Table 4-7 Estimated level of downstream adjustment (e.g., using the same surfactants with reduced 1,4-dioxane levels) and/or substitution in each restriction scenario (medium (low-high) %)

Indicator	RS1	RS2
Percentage of the affected portfolio of 'downstream user' sectors in scope that could be **adjusted (e.g., using the same surfactants with reduced 1,4-dioxane levels)) and/or substituted with alternatives**, in sales turnover terms.	**65%** (30%-100%)	**90%** (65%-100%)

Source: Ricardo analysis based on evidence collected from business stakeholders (N=38), follow-up interviews and expert input.

Businesses might thus transform upon the adoption of the restriction scenarios, which requires both one-off capital investments and adjustments to their operations that could lead to annual, recurring costs. These adjustment costs would include, illustratively: 1) one-off investments in removal technologies and/or new machinery and equipment necessary to adjust their manufacturing processes; and 2) additional recurring costs from more energy intensive production processes or a reduction in the productivity of existing processes, additional administrative activities under each of the restriction scenarios, etc.

Participants of the consultation were asked to provide estimates of the one-off and recurring annual costs they might incur to achieve the scale of reported transformation (i.e., adjusted, alternative and/or substitute operations). Their responses were reviewed and validated through follow-up interviews to confirm a medium scenario and possible lower and upper bounds. These are summarised in the Table 4-8 overleaf.

Table 4-8 Estimated additional one-off and recurring annual costs as a percentage of baseline turnover across value chain segments and restriction scenarios (medium (low-high) %)

Additional costs	Segment of the surfactants value chain	RS1	RS2
One-off costs (as a % of sales turnover)	Surfactants	**17.5%** (4.5% or 0%*)	**14.5%** (5%-30%)
	Downstream user sectors (average)	**2.0%** (0.2%-7.6%)	**0.5%** (0%-1.5%)
Annual costs (as a % of sales turnover)	Surfactants	**11.5%** (1% or 0%*)	**3%** (0.6%-12.3%)
	Downstream user sectors (average)	**1.8%** (0%-8%)	**0.3%** (0%-1.6%)

Source: Ricardo analysis based on evidence collected from stakeholders (N~30 upstream and N~30 downstream). * The 0% one-off and annual costs for the surfactants sector corresponds to the 'high' impact scenario with 100% withdrawal of production activity, in which case no adjustment costs would be undertaken.

For each of the 'downstream user' sectors in scope, the following Box presents the evidence of potential one-off and recurring costs that different companies might face under the restriction scenarios.

Box 4-3 Estimation of the one-off and recurring costs of potential downstream adjustments and/or substitution for specific downstream user' sectors in scope in the EU-27

The transformation timeline and costs for businesses, including both one-off capital investments and adjustments to their operations that could lead to annual, recurring costs, were estimated for each 'downstream user' sector in scope based on stakeholder consultation responses, follow-up interviews and expert input. The estimates were transformed into a percentage of baseline turnover to facilitate the analysis of the scale of total costs across these markets. These estimates are presented in Table 4-9 below.

Table 4-9 Estimated additional one-off and recurring annual costs as a percentage of baseline turnover across restriction scenarios for downstream user sectors in scope (medium (low-high) %)

Additional costs	Segment of the surfactants value chain	RS1	RS2
One-off costs (as a % of sales turnover)	Detergents and cleaning products	**2.9%** (0.3%-6.4%)	**0.9%** (0.1%-1.9%)
	Cosmetics and personal care products	**1%** (0.4%-2.3%)	**0.1%** (0.1%-0.3%)
	Paints, Coatings, Adhesives, Elastomers, and Printing Inks	**1.5%** (0.5%-5%)	**0.3%** (0.1%-0.9%)
	Chemical products for the textiles and leather sector	**2.6%** (0.7%-35.2%)	**0.8%** (0.2%-10.5%)
	Agrochemical products and applications	**8%** (3.3%-12.3%)	**2.2%** (0.9%-3.4%)
Annual costs (as a % of sales turnover)	Detergents and cleaning products	**0.8%** (0%-5.7%)	**0.2%** (0%-0.4%)
	Cosmetics and personal care products	**2.7%** (0.3%-15.7%)	**1.3%** (0.2%-4.3%)
	Paints, Coatings, Adhesives, Elastomers, and Printing Inks	**1%** (0%-2%)	**0.2%** (0.1%-0.4%)

	Chemical products for the textiles and leather sector	**4.2%** (0.5%-14.4%)	**1.3%** (0.2%-4.3%)
	Agrochemical products and applications	**1.8%** (0.5%-4.9%)	**0.5%** (0.1%-1.3%)

Source: Ricardo analysis based on evidence collected from downstream user stakeholders (N~30).

This evidence suggests that **companies in the sectors in scope might undergo significant transformation, which could lead to large one-off and recurring costs under RS1 and RS2. For example, in some cases, capital expenditures required might be equivalent to 3-4 times that in the baseline** (see Box 3-2). In addition, these costs might be incurred in the context of a reduction of domestic manufacturing activity, which is assessed in more depth in the following section. Under RS1, fewer yet costlier adjustments are estimated across 'downstream user' companies for which 'alternative' or 'substitute' options are technically viable. The Net Present Value of the estimated one-off and recurring costs over the period 2026-2040 as well as the annualised or annual-equivalent costs were estimated. The results are presented in Table 4-10 below. The Appendices set out the methodologies employed in more detail[59].

Table 4-10 Total 'adjustment costs' estimated over 2026-2040 across value chain segments and restriction scenarios, as NPV over the period or annualised (medium (low-high) bn). Note that bn refers to billions.[60]

Additional costs	Segment of the surfactants value chain	RS1	RS2
Net Present Value of total 'adjustment' costs over the period (2026-2040)	**Surfactants**	€8 bn (€1 bn with no upper bound*)	€4 bn (€1-13 bn)
	Downstream user sectors (average)	€35 bn (€5-108 bn)	€8 bn (€1-32 bn)
Annualised or annual-equivalent 'adjustment costs'	**Surfactants**	€0.6 bn/year (€0.1 bn/y with no upper bound*)	€0.3 bn/year (€0.1-1 bn/y)
	Downstream user sectors (average)	€3 bn/year (€0.4-9 bn/y)	€0.7 bn/year (€0.1-3 bn/y)

*Source: Ricardo analysis based on evidence collected from stakeholders and publicly available, Eurostat datasets. * Please note that the one-off and annual costs for the surfactants sector in the 'high' impact scenario corresponds to 100% withdrawal of production activity, in which case no compliance costs would be incurred, and negative impacts on businesses would primarily be a loss of business opportunity/ financial return on the capital invested.*

Adjustment costs that might be incurred by the manufacturers of surfactants up to 2040 could be large and might surpass €4 billion in Net Present Value under RS1 and RS2, equivalent to over €300 million each year over the period of assessment. These costs reflect the scale of the transformation that would be required across these companies in the EU-27 to meet the requirements under the restriction scenarios.

These estimated costs are small compared to the potential implications downstream, in sectors where surfactants play a critical role for large proportions of their portfolio of products and/or manufacturing processes.

Adjustment costs to 2040, further downstream, could surpass €8 billion in Net Present Value, equivalent to around €700 million each year over 2026-2040. Even if the potential for emissions of 1,4-dioxane is relatively low across some of these sectors, the reliance on surfactants for production activity, the critical role these substances play across these sectors and the scale of transformation required demonstrate

[59] Please note that a 3% real discount rate has been employed in line with the latest guidelines.
[60] Ibid 43

the difficulties that around 15,000 companies in the EU-27 may face upon the introduction of restriction scenarios under considerations.

Finally, despite these transformative investments and expenditures, industrial activity in the EU-27 could likely be negatively affected and reductions with knock-on economic and social implications have been estimated in the following section.

4.1.1.3 Estimated impacts on industrial activity in the EU-27

The surfactants manufacturing activity in the EU-27 might also be reduced, at least partially, under the restriction scenarios. Baseline products which do not comply with the requirements set out under the restriction scenarios (i.e., "affected portfolio") nor can be adjusted and/or replaced with alternatives (i.e., levels of possible 'substitution') would be withdrawn from the EU-27 market. Based on the evidence presented earlier, it is estimated that the potential reductions in sales that the surfactants industry could face might be sizeable, and equivalent to around 55% [20-100%] of baseline turnover under RS1 and 10% [0-25%] under RS2. These estimates and the quantified uncertainties are presented in Table 4-11.

Table 4-11 Estimated reduction in the sales turnover of surfactants in the EU-27 against the 2040 baseline (medium (low-high) %[61])

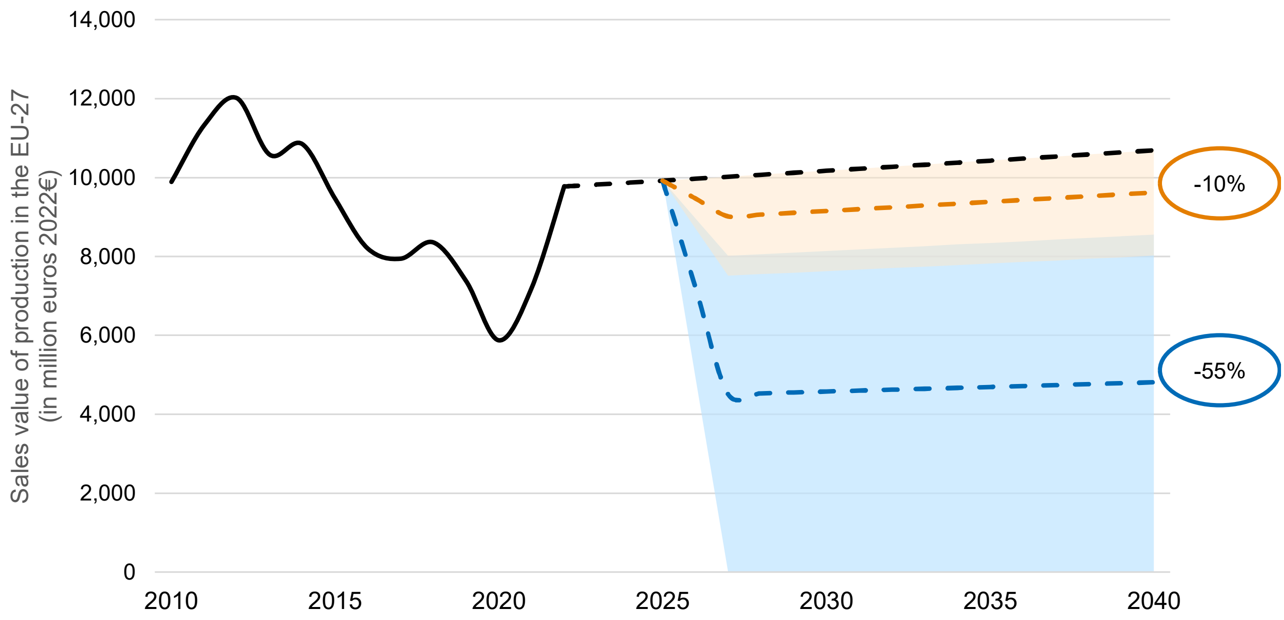
Indicator	RS1	RS2
Estimated percentage **reduction of the sales turnover of manufacturing of surfactants in the EU-27, against the baseline**	**-55%** (-20% – -100%)	**-10%** (0% – -25%)

Source: Ricardo analysis based on evidence collected from business stakeholders.

That is, billions of euros in sales across the EU-27 could be lost, when compared to the baseline. These 'losses' under RS2 could be relatively limited, especially in comparison with the more pronounced and transformational effects that the surfactant manufacturers could face under RS1. As an illustration, the evidence collected suggests that an average of €5bn/year of sales turnover of manufacturing of surfactants could be lost under RS1 and €1bn/year under RS2. The Figure overleaf represents these estimated impacts against baseline sales turnover levels across the restriction scenarios.

[61] Please note that in this case, a "low" estimate refers to the low impact scenario, as these are representing estimated reductions against the baseline. This applies to any other table with negative figures.

Figure 4-1 Sales turnover of manufacturing of surfactants in the EU-27 across the baseline and restriction scenarios (€ million)



Notes: Please note that the black line represents the baseline, blue line for RS1 and orange line for RS2; shaded areas represent the uncertainties. Source: Ricardo analysis based on evidence collected from stakeholders and publicly available Eurostat datasets.

The overall knock-on effects that this might have on the 'downstream user' industries might be negative and pronounced but proportionally lower than the impacts faced by upstream manufacturers in the EU-27, given the higher rates of potential transformation (e.g., adjustments and/or substitution) reported by survey respondents from these markets. The estimation of the impacts on these downstream user sectors in scope is explored in the Box below.

Box 4-4 Estimation of the reduction in the production for downstream user' sectors in scope in the EU-27

Evidence of the potential impacts of the restriction scenarios across the downstream markets in scope was explored in depth, and the estimates of potential withdrawal rates and the quantified uncertainties are presented in Table 4-12 below.

Table 4-12 Estimated reduction in the sales turnover of downstream user sectors in scope in each restriction scenario (medium (low-high) %)

'Downstream user' industry	Estimated percentage reduction of the sales turnover of 'downstream user' markets in scope in the EU-27, against the baseline under…	
	RS1	RS2
Detergents and cleaning products	**-25%** (0% – -90%)	**-5%** (0% – -35%)
Cosmetics and personal care products	**-10%** (0% – -40%)	**-2%** (0% – -10%)
Paints, Coatings, Adhesives, Elastomers, and Printing Inks	**-30%** (-5% – -75%)	**-10%** (0% – -20%)
Chemical products for the textiles and leather sector	**-55%** (-20% – -70%)	**-25%** (-10% – -40%)
Agrochemical products and applications	**-35%** (0% – -75%)	**-5%** (0% – -30%)

Source: Ricardo analysis based on evidence collected from business stakeholders.

Overall, it is estimated that the potential reductions in sales that the downstream industries in scope might face could be equivalent to around 25% [5-60%] of baseline turnover under RS1 and 5% [0-20%] under RS2. As an illustration, this would mean that an average of €12bn/year of downstream production activity could be lost against the baseline under RS2, or ~4 times greater under RS1. These estimates depend on evidence collected from companies, which can be overestimating the criticality of surfactants within their manufacturing processes and products. These uncertainties have thus been quantified to the extent that was possible for consideration in this Study. Table 4-13 presents the estimated reductions in industrial sales across the 'downstream user' markets in scope of the Study.

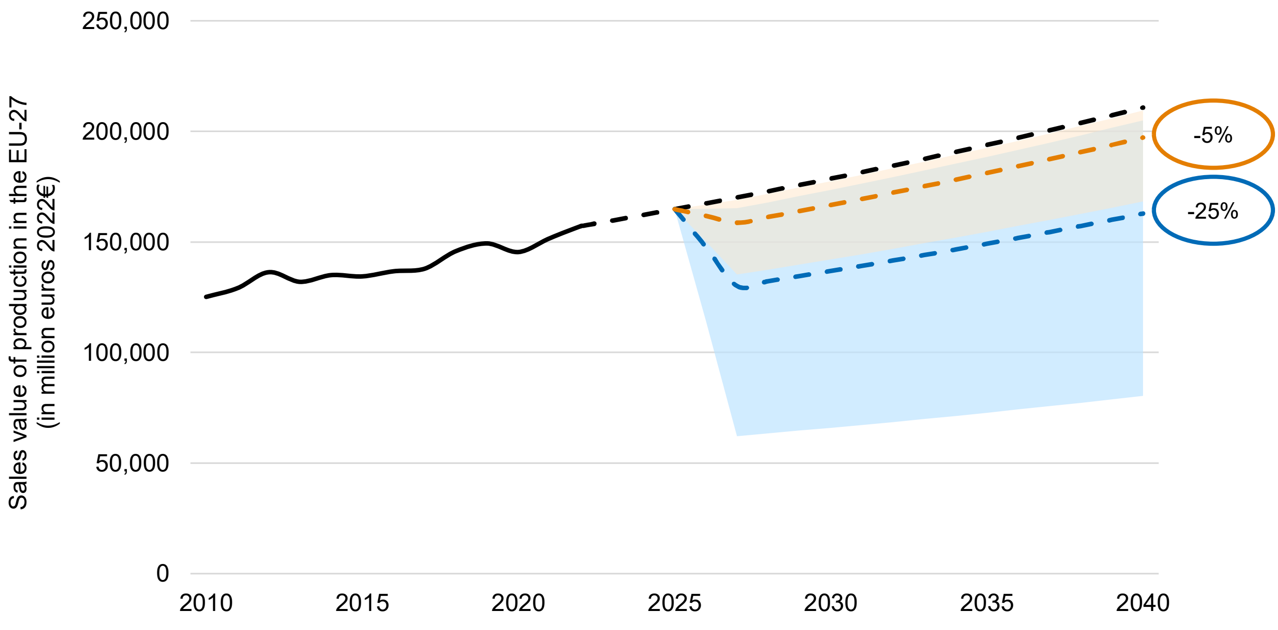
Table 4-13 Estimated reduction in the sales turnover of the downstream user sector in the EU-27 against the 2040 baseline (medium (low-high) %[62])

Indicator	RS1	RS2
Estimated percentage **reduction of the sales turnover of 'downstream user' markets in scope in the EU-27, against the baseline**	**-25%** (-5% – -60%)	**-5%** (0% – -20%)

Source: Ricardo analysis based on evidence collected from business stakeholders.

The Figure below presents these estimated impacts against baseline production levels across the restriction scenarios.

Figure 4-2 Sales turnover of the five 'downstream user' EU-27 markets in scope across the baseline and restriction scenarios (€ million)



Notes: Please note that the black line represents the baseline, blue line for RS1 and orange line for RS2; shaded areas represent the uncertainties. Source: Ricardo analysis based on evidence collected from stakeholders and publicly available Eurostat datasets.

In conclusion, both upstream and downstream companies could face significant challenges under each restriction scenario, incurring billions of additional 'adjustment costs' each year and reducing their production activity and thus economic footprint in the EU-27 when compared against the baseline. These impacts could be sizeable under RS2 and even more severe under RS1.

[62] Please note that in this case, a "low" estimate refers to the low impact scenario, as these are negative numbers representing estimated reductions against the baseline. This applies to any other table with negative figures.

4.1.2 Innovation and research

In the face of increasing regulation and growing environmental concerns surrounding 1,4-dioxane, **industries manufacturing or reliant on surfactants containing 1,4-dioxane in active matter are being compelled to invest in research and development (R&D) of alternatives to the baseline manufacturing processes and/or product design.** The majority of companies consulted for this Study suggested that they perform R&D activities in the EU-27: over 85% of the manufacturers of surfactants (N=42) and around 90% of the 'downstream user' companies (N=44). The surfactant manufacturer participants also reported that more than 30% of their investments were devoted to identifying and developing product alternatives.

Surfactant manufacturers and 'downstream user' companies have also provided evidence suggesting there are potential alternatives already available or which could be brought to the market in response to the restriction scenarios for a proportion of the baseline applications. Surfactant manufacturers (N=33) indicated average lead times of 3-4 years for bringing adjusted products to market and 3-5 years for bringing new products to market. 'Downstream user' companies' (N=37) responses suggested broadly similar but slightly longer lead times, at an average of 3-6 years for bringing adjusted products to market and 3-7 years for bringing new products to market, with the paints, coatings, adhesives, elastomers and printing inks sector and the agrochemical products and applications sector reporting much longer lead times than the other sectors. The average lead times for bringing adjusted products to market ranged from 3-6 years cosmetics and personal care products sector (N=10), 3-4 years for the detergents and cleaning products sector (N=15), 2-3 years for the chemical products for textiles and leather sector (N=5), 7-8 years for the paints, coatings, adhesives, elastomers and printing inks sector (N=5) and 8-11 years for the agrochemical products and applications sector (N=5). Similarly, the average lead times for bringing new products to market ranged from 3-6 years cosmetics and personal care products sector (N=10), 3-5 years for the detergents and cleaning products sector (N=15), 2-3 years for the chemical products for textiles and leather sector (N=5), 6-9 years for the paints, coatings, adhesives, elastomers and printing inks sector (N=5) and 11-13 years for the agrochemical products and applications sector (N=5).

The findings from a rapid review of this evidence, complemented by the outputs of a literature review, are summarised in the Box below.

Box 4-5 Alternatives to surfactants containing 1,4-dioxane across the supply chain

In response to the two restriction scenarios, **manufacturers and importers** of surfactants will have to decide between:

- **Adjusting and/or transforming their production of products (or their import) so the manufactured and/or imported products** contain levels of 1,4-dioxane below 1 ppm or 10 ppm as required under the different scenarios; for example, through the introduction of 1,4-dioxane-free alternatives and/or the use of techniques (such as the stripping of 1,4-dioxane) to lower the concentration of 1,4-dioxane in the produced surfactants; and/or
- **Ceasing production of surfactants which contain the levels of 1,4-dioxane targeted by the restriction scenarios** (i.e., ≥1ppm, and ≥10 ppm).

Through the stakeholder consultation and literature research, 29 alternatives to baseline surfactants have been identified, these are listed and discussed further in Appendix 5. Notably, these alternatives include:

- Sodium dodecyl sulphate (CAS no. 151-21-3),
- Sodium C14-16 Olefin Sulfonate (CAS no. 68439-57-6)
- Rhamnolipids, Sugar derivs (CAS no. 4348-76-9),
- Sodium methyl cocoyl taurate (CAS no. 61791-42-2),
- Polyglyceryl fatty ester (CAS no. 67784-82- 1),
- Sodium alkylbenzenesulphonic acid salt (CAS no. 68411-30-3),
- D-glucopyranose, oligomeric, decyl octyl glycosides (CAS no. 68515-73-1),
- Sulphuric acid, mono-C12-14-alkyl ester, sodium salts (CAS no. 85586-07-8).

The suggestions include alternatives with 1,4-dioxane concentrations below 10 ppm, 1 ppm or non-EO based surfactants, which have no 1,4-dioxane content at all; and they generally appear to be horizontal alternatives, that is, they could be used in, or are currently used across, many of the downstream sectors in scope.

This said, it has also been reported that there are specific EO-based surfactants such as fatty acids, fatty amines, and other ethoxylates that can be difficult to substitute. The degree of surfactant ethoxylation affects the hydrophilic-lipophilic balance (HLB) of the surfactant, which is *the balance between contributions (size and strength) of the hydrophilic and lipophilic moieties of a surfactant molecule*"[39]. Replacement of ethoxylated surfactants with alternatives could affect certain properties related to the HLB notably, and consequently impact the performance of the surfactant.

In these cases, lowering (stripping) of the 1,4-dioxane content from ethoxylated surfactants may be a preferable approach to meet the requirements under the restriction scenarios, where that is viable. In particular, stripping of the 1,4-dioxane content will increase the energy consumption in isolation. However, the effect of stripping on the overall energy consumption is uncertain as there would be the need to consider the entire manufacturing process and any potential changes. The energy consumption during the stripping process and the treatment of 1,4-dioxane containing wastewater (including the risk management measures associated with the treatment of wastewater) are expected to result in higher production costs, which can affect the viability of implementation.

Finally, some respondents highlighted the issue of 1,4-dioxane formation during storage, indicating that the stripping of 1,4 dioxane may not prevent 1,4-dioxane content in the final delivered product.

Additional evidence gathered through stakeholder engagement suggests that companies have the capacity and skills to transform at least parts of their production activity if the restriction scenarios were adopted, albeit this would not be without challenges. On the one hand, more than 90% of businesses in the surfactants value chain have experience with adjusting surfactant products (N=74) and 80% of businesses in the surfactants value chain have experience in the development of new surfactant products (N=71). On the other hand, more than 95% of the businesses reported facing some hurdle when bringing alternative or new surfactant products to market (N=79). Companies manufacturing surfactants reported high regulatory costs, worsened product performance, capital investment requirements, and relatively high operating costs as the most significant hurdles to bringing new products to the market; whilst companies downstream found worsened product performance, high regulatory costs, relatively high operating costs and complex and difficult-to-meet legal requirements as the main hurdles they face.

Despite this, businesses reported that the performance and cost of these potential alternatives could have negative implications, when compared to the baseline (N>46). In particular, companies highlighted uncertainty and lack of awareness of the extent to which at least some of the baseline applications could be replaceable with the alternatives identified so far and how these might perform. Companies also considered that it is very likely costs of production could increase, at least during the 5-10 years after adoption of the restriction scenarios. These have been estimated previously based on their input (see Section 4.1.1.2).

Whilst additional investment in R&D could have positive impacts in the EU-27 across economic and environmental dimensions; the regulatory push could also result in the misallocation of resources towards lower yield or less productive investments, reducing innovation when compared to the baseline.

4.1.3 Global competitiveness and trade

The cost of doing business in the EU-27 might increase across both restriction scenarios, which could deter the competitiveness of EU-27 businesses operating in the surfactants value chain. Both surfactant manufacturers and downstream companies that participated in the online survey agree and report, on average, negative[63] (-2) or weakly negative (-1) impacts on their global competitiveness, under RS1 and RS2 respectively (N=77). They also report that these impacts could be especially driven by increases in relative costs of production when compared to third countries.

The estimated EU-27 industry's loss in global competitiveness could also be exacerbated by second order effects, such as the reduction in economies of scale, which could even make these activities relatively costlier and less efficient in a global context. A reduction in the size of domestic manufacturing could also negatively

[63] Company participants were asked to report whether a range of dimensions, such as global competitiveness, would be positively or negatively affected on a scale of -5 (strongly negative) to +5 (strongly positive) impacts. See Annexes for the consultation synopsis.

affect R&D capacity within the EU-27 and reduce the adaptability of companies to changes in market demand, further hindering the global competitive position and the functioning of the EU-27 internal market.

In both upstream and downstream segments of the surfactants value chain, the EU's manufacturing activity could decline (see Section 4.1.1.3). Exports are also likely to decline; however, impacts on imports are very uncertain and cannot be quantified given the available evidence. It is possible that the increasing costs of production for companies may lead to a partial relocation of manufacturing activities to third countries and an increase in import dependency within the EU-27. However, the scale of this is very uncertain and conclusive evidence has not been identified that could support a quantitative characterisation of this hypothesis.

4.1.4 Other (wider) economic impacts

In summary, there could be significant negative (wider) economic impacts on the EU society, including a potential loss of a noticeable number of quality job opportunities when compared to the baseline; and negative impacts on the availability, performance and cost of final products for consumers and households, affecting their daily lives in ways that could be impactful.

4.1.4.1 Employment

The **restriction scenarios under consideration could lead to a reduction in the jobs supported across the surfactants industry as well as the 'downstream user' industries**, directly as a result of the negative impacts on industrial activity estimated in earlier sections. The reductions in direct employment across the supply chain have been estimated to be proportionately lower than the reduction in sales turnover, based on historical trends and inputs from the businesses that participated in the online survey. This is partly driven by the rigidity of the labour market and the need to retain employees to meet any additional regulatory requirements. For example, evidence on the impacts of REACH[64] suggests that additional compliance costs led to increased labour requirements in the chemicals sector, all else held equal; not only due to needing additional staff but also due to additional remuneration, skills, training and/or retraining costs.

Estimated, potential job losses under the restriction scenarios are presented in the Table below.

Table 4-14 Average impacts on annual employment supported, in FTE, by the surfactants industry from 2026-2040, when compared to the baseline (medium (low-high))

Indicator	RS1	RS2
Direct **employment supported** by the surfactants industry against the baseline (FTE)	- 4,000 FTE (-1,000 – -12,000)	- 600 FTE (0 – -2,000)

Source: Ricardo analysis based on evidence collected from stakeholders and publicly available, Eurostat datasets.

Even more employment opportunities could be lost across the 'downstream user' sectors in scope of this Study. Surfactants play a critical role in some of these sectors, implying that the scale of impacts on employment in these sectors might also be large. The outputs of this analysis are presented in the Box below.

Box 4-6 Estimation of the reduction in the employment supported by specific downstream user' sectors in scope in the EU-27

Estimated impacts on industrial activity across the downstream user sectors, historical evidence and evidence from the consultation were used to estimate how the levels of employment supported by downstream sectors could be affected under each restriction scenario. These are presented in the Table below.

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

Table 4-15 Average impacts on annual employment supported, in FTE, by specific 'downstream user' sectors from 2026-2040, when compared to the baseline (medium (low-high))

'Downstream user' industry	Direct employment supported by 'downstream user' sectors in scope against the baseline (FTE) under…	
	RS1	RS2
Detergents and cleaning products	- 15,000 FTE (0 – -54,000)	- 5,000 FTE (0 – -20,000)
Cosmetics and personal care products	- 13,000 FTE (0 – -64,000)	-3,000 FTE (0 – -13,000)
Paints, Coatings, Adhesives, Elastomers, and Printing Inks	- 22,000 FTE (-6,000 – -50,000)	- 6,000 FTE (0 – -11,000)
Chemical products for the textiles and leather sector	- 7,000 FTE (-2,000 – -8,000)	- 3,000 FTE (-1,000 – -5,000)
Agrochemical products and applications	- 6,000 FTE (0 – -14,000)	- 1,000 FTE (0 – -6,000)

Source: Ricardo analysis based on evidence collected from business stakeholders.

That is, **tens of thousands of jobs could be lost across the downstream surfactants value chain under each restriction scenario.** Overall estimates of potential employment impacts are presented in the Table below.

Table 4-16 Average impacts on annual employment supported, in FTE, by the 'downstream user' sectors from 2026-2040, when compared to the baseline (medium (low-high))

Indicator	RS1	RS2
Direct **employment supported** by 'downstream user' sectors in scope against the baseline (FTE)	- 63,000 FTE (-8,000 – -190,000)	- 18,000 FTE (-1,000 – -55,000)

Source: Ricardo analysis based on evidence collected from stakeholders and publicly available, Eurostat datasets.

A reduction in employment (FTE) across surfactant manufacturers and downstream markets might also lead to decreases in disposable income and thus consumption in the economy, which could have additional, induced effects, leading to further employment losses against the baseline. Input-Output matrices were used to characterise these multiplier effects in the EU economy and estimate the additional employment losses due to induced effects. The Appendices describe the methodology in more detail.

In summary, thousands of quality jobs could potentially be lost in the EU from the adoption of the restriction scenarios, with knock-on socioeconomic consequences. The total impact estimates are presented in the Table below.

Table 4-17 Annual average impacts on employment supported, in FTE, by the surfactants value chain from 2026-2040 (medium (low-high))

Indicator	RS1	RS2
Total (direct, indirect and induced) impacts on the **employment supported** by the industries in scope, against the baseline (FTE)	- 190,000 FTE (-25,000 – -577,000)	- 45,000 FTE (-3,000 – -162,000)

Source: Ricardo analysis based on evidence collected from stakeholders and publicly available, Eurostat datasets.

4.1.4.2 Consumers and households

The availability of surfactants and 'downstream user' products containing and/or requiring 1,4-dioxane would be reduced, especially under RS1, which could negatively affect consumer choice. Surfactants have critical applications and/or roles to play across a diverse range of consumer and industrial goods, including detergents, cleaning products, cosmetics, personal care products, paints, agrochemical applications etc. Lower availability of surfactants might lead to the partial disruption of downstream supply chains and lead to lower supply in consumer products, some of which might perform key functions in the lives of European households.

The performance of products could also be negatively affected under each of the restriction scenarios. Surfactants are valued for their unique properties, such as solubilising, cleaning, foaming and providing suspending and stabilising power, which contribute to the performance and functionality of industrial and consumer products. For example, ethoxylated surfactants used as adjuvants increase the crop protection properties of agrochemicals, improving pesticide efficacy by increasing foliar uptake[65]. Ethoxylated surfactants are used in the textile and leather sectors because of their specific properties (variability in chain length, degree of ethoxylation and their readily accessible functional groups). Ethoxylated surfactants are used in detergents for their performance and skin compatibility, whilst they have been used to replace solvent based VOC based coatings and adhesives.[66] Substituting these substances with alternative materials may not always replicate the same level of functionality or may introduce unforeseen compatibility issues, leading to potential compromises in product performance. For example, service lives are likely to be reduced when compared to the baseline.

Product costs and thus consumer accessibility may also be negatively affected under each of the restriction scenarios. As supply chains adjust to a reduction in supply of surfactants, prices could rise and additional costs purchasing available surfactants and/or sourcing alternative surfactants could increase, exacerbated by the necessary investments in new technologies, machinery and product adjustments where applicable. Higher costs of production could, to some extent, be passed on to final consumers in the form of higher, final product prices. Any supply-side reductions on product availability could drive prices up even further, exacerbating these impacts on consumer prices and product accessibility.

Overall, consumers and households are likely to be negatively affected directly and indirectly. Companies participating in the online survey predominantly agree that these restriction scenarios could have a negative or very negative impact on consumers and the availability of products.

4.1.5 Overall economic impacts

In summary, the EU's economy overall could be negatively affected by the restriction scenarios, with a reduction in the surfactants value chain production activity and, thus, contribution to the EU's Gross Domestic Product (GDP) against the baseline. The contribution of the EU surfactants value chain to Gross Value Added (GVA) in the EU could be reduced by an estimated €45 billion/year or €5 billion/year under RS1 and RS2 respectively from 2026-2040. The estimated effects on GVA contributions against the baseline are summarised in the Table below.

Table 4-18 Overview of the economic impact assessment for each restriction scenario against the baseline

Indicator	RS1	RS2
Total impacts on the GVA contributions of the industries in scope, against the baseline (including *direct, indirect, induced effects*)	**- € 45 billion/year** (-7 – -130 billion/year)	**- € 5 billion/year** (-0.5 – -20 billion/year)

Source: Ricardo analysis based on evidence collected from stakeholders and publicly available, Eurostat datasets.

Albeit uncertain, it is assumed that, for the purposes of the qualitative assessment, innovation could be positively affected even if the scale of benefits would be smaller than the scale of the overall negative economic effects of each of the restriction scenarios. In fact, the estimated, overall negative

[65] Mariano J. L. Castro, Carlos Ojeda, Alicia Fernandez Cirelli (2013). Advances in surfactants for agrochemicals. Environmental Chemistry Letters, 12, 85-95.

[66] Ricardo (2024). CESIO Response to the UBA Questionnaire. Final Report.

impacts on the EU economy already take into account the mitigating effects achieved through research and development efforts to replace baseline products and manufacturing processes with alternatives that comply with the restriction scenarios.

The increased costs of doing business in the EU could further deter the EU industry's global competitiveness position.

The economic impact conclusions are summarised qualitatively in the Table below, using the scoring framework described in Section 2 and, in more detail, in the Appendices (especially Appendix 1).

Table 4-19 Qualitative economic impact ratings

Economic impacts	Restriction Scenario 1 (against baseline)	Restriction Scenario 2 (against baseline)
Industrial activity in the EU-27	-5.0	-1.5
Innovation and research	+1.0	+0.5
Global competitiveness and trade	-1.0	-0.5
Other wider economic impacts (Employment and Consumers and households)	-3.0	-1.5
Overall economic impacts*	**-3.5**	**-1.5**

*Source: Ricardo analysis based on the evidence presented in this Study. *Rounded figures*

4.2 ENVIRONMENTAL IMPACTS

This section presents the assessment of the shortlisted environmental impacts of the restriction scenarios in scope of this SEA against the baseline. These impacts have been assessed qualitatively and where possible quantitatively. This section consists of the following:

- Section 4.2.1 – A recap of the baseline
- Section 4.2.1 – Quality of natural resources (water)
- Section 4.2.3 – Waste production and treatment
- Section 4.2.4 – Effects on the use of resources and energy

4.2.1 Recap of the baseline

The concerns of 1,4-dioxane in the environment are related to its persistence and mobility. 1,4-dioxane has an overall persistence (P_{oc}) of 1771 days, which has been calculated using the OECD tool for Long Range Transport Potential.[67] The substance has also been classified as mobile in the environment based on its water solubility, partition coefficient (log K_{ow}) and its detection in groundwater, surface water and drinking water. 1,4-dioxane has been concluded not to be bioaccumulative based on the available literature. Concerning its ecotoxicity, chronic/acute effects are only observed at high concentrations[68].

Emissions of 1,4-dioxane from EO-based surfactants to the environment are not expected to reduce under the baseline scenario. Under the baseline scenario (section 3.1.4), the emissions of 1,4-dioxane are presented in the following table.

[67] ECHA (2021). Proposal for Identification of a Substance of Very High Concern on the Basis of the Criteria set out in REACH Article 57 – 1,4-dioxane. Available from: https://echa.europa.eu/documents/10162/435f5245-3bad-5ff5-65f3-0b279c9b6847

[68] United States Environmental Protection Agency (2024). ECOTOX Knowledgebase. Available from: https://cfpub.epa.gov/ecotox/search.cfm

Table 4-20 Baseline emissions

Indicator	Emissions of 1,4-dioxane (tpa)		
	Low	Medium	High
Baseline emissions (manufacturers of surfactants)	8.5	19.5	35
Baseline emissions (downstream user sectors in scope)	5.5	13	24

4.2.2 Quality of natural resources (water)

Within this section, the potential environmental impact on the quality of natural resources for the restriction scenarios are considered in respect of water compartments for the environment (i.e. groundwater and surface water). More specially, this section assesses the following aspects:

- Section 4.2.2.1: Reduction in emissions of 1,4-dioxane to water for RS1 and RS2.
- Section 4.2.2.2: The effect of the reduction of emissions on the presence of 1,4-dioxane in water and the implications for environmental quality and resources.

4.2.2.1 Emissions reductions

With the entry into force of the proposed REACH restriction, it is estimated that there would be reductions in emissions of 1,4-dioxane from surfactants. No estimates of 1,4-dioxane emissions to water are available in the relevant ECHA documentation for 1,4-dioxane (i.e. within the Annex XV report and in the previous calls for evidence by ECHA) and the scientific literature.

The emissions of 1,4-dioxane under each of the restriction scenarios has been estimated, however these are caveated as the reported levels of 1,4-dioxane in surfactants is variable. The current levels of 1,4-dioxane in surfactants used for these calculations come from stakeholder consultation and literature review. A worst-case assumption has been used for the emission estimates with 100% of the surfactant(s) going down the drain.

These estimates are for manufacturers of surfactants and for the five downstream sectors in scope, namely Detergents and cleaning products; Cosmetic and personal care products; Paints, Coatings, Adhesives, Elastomers, and Printing Inks; Chemical products for textiles and leather; and Agrochemical products and applications. The emissions for RS1 are presented in Table 4-21 and the emissions for RS2 are presented in Table 4-22. These emissions also take into account the affected portfolio under both restriction scenarios.

Table 4-21 Potential reduction in emissions for RS1

Sector	Emissions of 1,4-dioxane (tpa) under RS1	Reduction of emissions compared to the baseline
Manufacturers of surfactants	Low scenario: 1 Medium scenario: 0.5 High scenario: 0	Low scenario: 90% Medium scenario: 95% High scenario: 100%
DU sectors	Low scenario: 1 Medium scenario: 1 High scenario: 0.5	Low scenario: 80% Medium scenario: 90% High scenario: 98%

Table 4-22 Potential reduction in emissions for RS2

Sector	Emissions of 1,4-dioxane (tpa) under RS2	Reduction of emissions compared to the baseline
Manufacturers of surfactants	Low scenario: 5.5 Medium scenario: 6.5 High scenario: 6	Low scenario: 35% Medium scenario: 65% High scenario:80%
DU sectors	Low scenario: 2.5 Medium scenario: 5 High scenario: 5	Low scenario: 50% Medium scenario: 60% High scenario:80%

Under RS1, the remaining emissions of 1,4-dioxane would be equivalent to 0-10% of the baseline emissions for manufacturers of surfactants and 2-20% of the baseline emissions for the downstream user sectors. These estimates account for a reduction to 1 ppm or less of 1,4-dioxane in the EO-based surfactants. Under RS2, the remaining emissions would be 20-65% of the baseline emissions for manufacturers of surfactants and 20-50% for the downstream user sectors. These estimates account for a reduction to 10 ppm or less of 1,4-dioxane in the EO-based surfactants used by the in scope downstream sectors.

It has not been possible due to the limitations with the data to calculate the steady-state environmental stock for the scenarios.

4.2.2.2 What the emission reductions means for the presence of 1,4-dioxane in water and the implications on environmental quality and resources

A reduction in emissions as a result of a restriction could result in a positive environmental impact for the presence of 1,4-dioxane in water. As discussed in section 4.2.1, 1,4-dioxane is classified as a PMT (Persistent, Mobile, and Toxic) substance. For PMT, T is not considered for 1,4-dioxane for the environment..

The evidence presented in the ECHA Annex XV report for 1,4-dioxane suggests that the persistence of 1,4-dioxane gives rise to concerns for the environment and its overall persistence has been calculated as 1771 days for 1,4-dioxane in the environment (using the OECD tool for LRTP), which is discussed as being similar to Persistent Organic Pollutants (POPs)[69]. Concerns are also raised in the ECHA Annex XV report for the presence in water, which is also linked to its persistence, as there have been several studies showing the occurrence of 1,4-dioxane in both source water and drinking water[70]. The persistence of 1,4-dioxane has also been investigated by KWR in which a DT50 of >10,000 days was derived using single first-order in surface water[71]. Regarding the ecotoxicity of 1,4 dioxane as discussed in Section 3.1.4, low toxicity has been observed in the literature[72] and following on this, reported ecotoxicity studies in the ECHA Annex XV report discusses that effects are only observed at high concentrations >100 mg/L (>100 ppm). The average levels of 1,4-dioxane reported by stakeholders is below 100 ppm, thus this is not considered further. The main concern raised for toxicity is the classification of 1,4-dioxane as a carcinogenic 1B for human health and its presence in drinking water which is out of scope for this SEA.

Under the baseline scenario, where there would be no reduction in emissions, due to the high half-life for 1,4-dioxane in water, the environmental concentrations would remain, with consideration needed for their steady state environmental stock based on degradation mechanisms. This would be expected to have a negative impact for persistence in water compartments based on the current emission levels to water. It is not possible from the evidence presented in the literature to estimate the current levels of 1,4-dioxane in surface water and groundwater in the EU-27 or the contribution of these levels from EO-based surfactants in the EU-27.

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[69] ECHA (2021). Proposal for Identification of a Substance of Very High Concern on the Basis of the Criteria set out in REACH Article 57 – 1,4-dioxane. Available from: https://echa.europa.eu/doctuments/10162/435f5245-3bad-5ff5-65f3-0b279c9b6847

[70] De Boer S et al. (2022). 1,4-dioxane in German drinking water: Origin, occurrence, and open questions. Current Opinion in Environmental Science & Health, 100391.

[71] KWR (2020). Persistence of gabapentin, 1H-benzotriazole, diglyme, DTPA, 1,4-dioxane, melamine and urotropine in surface water. Available from: https://edepot.wur.nl/539038

[72] United States Environmental Protection Agency (2024). ECOTOX Knowledgebase. Available from: https://cfpub.epa.gov/ecotox/search.cfm

With respect to the two restriction scenarios, a reduction in the concentration of 1,4-dioxane from surfactants emitted to the environment is expected, which would have a positive impact. Under both restriction scenarios, there would be lower emissions and thus lower exposure. Under RS1, there is assumed to be a reduction of emissions of between 90%-100% for manufacturers of surfactants and 80%-90% for the downstream user sectors to water sources based on 100% of the emissions going 'down the drain' as described in Section 4.2.2.1. Consequently, the tonnage per annum (tpa) of 1,4-dioxane emissions from surfactants to the water would decrease from 8.5-35 tonnes for manufacturers of surfactants to 0-1 tonnes under RS1 and from 5.5-24 tonnes to 0.5-1 tonnes for the downstream users. Under RS2, the reduction in emissions of 1,4-dioxane in water would also have a positive impact on the quality of emissions to a lesser degree than RS1. The emissions to water from EO-based surfactants would decrease by 35%-80% (from 8.5-35 tpa to 5.5-6.5 tpa) for manufacturers of surfactants and by 50%-80% (from 8.5-35 tpa to 2.5-5 tpa).

On the other hand, due to the high persistence of 1,4-dioxane, the emissions to water from surfactants currently on the market as well as emissions from other sources[73] (emission data for these sources are not available) mean that the risks for persistence cannot be disregarded.

It is considered that any environmental benefits from the emissions reduction (described in Section 4.2.2.1) from the two scenarios for persistence will be proportional and thus higher under restriction scenario 1.

4.2.3 Waste production and treatment

Within this section, the potential environmental impact on waste production and treatment for the restriction scenarios are considered. More specifically, this section addresses the following aspects:

- Section 4.2.3.1: Reduction in emissions on waste production and treatment
- Section 4.2.3.2: Implications on a wastewater limit value for 1,4-dioxane

4.2.3.1 Reduction in emissions on waste production and treatment

Surfactants containing 1,4-dioxane as an impurity have a wide variety of uses/applications. These uses are captured within the two restriction scenarios under consideration. Surfactants containing 1,4-dioxane as an impurity are used in a wide variety of products such as personal care products (i.e. body wash, shampoo and creams), home care products (i.e. laundry detergents and dishwashing detergents), paints and in the processing of textiles and leather[74]. The waste streams for these products are wastewater (i.e. 'down the drain')[75]. In sewage treatment plants, no removal of 1,4-dioxane is expected from the technologies currently used.

To reduce the levels of 1,4-dioxane in surfactants/surfactant products, stripping of 1,4-dioxane can be performed. Following this, the wastewater containing the stripped 1,4-dioxane can be treated by technologies such as advanced oxidation processes (AOP) to reduce/destroy the 1,4-dioxane in the wastewater. The use of these technologies is required as conventional wastewater technologies are unable to effectively remove 1,4-dioxane[76]. The use of AOP has been shown to reduce 1,4-dioxane levels in Wastewater Treatment Plants (WWTPs), with 1,4-dioxane decreases observed from >110 µg/L in July 2017 to < 8 µg/L in July 2018 in the WWTP discharge at two industrial sites on the River Lech and its tributary, the Wertach river[77]. Other potential treatment options can include adsorption for extracting 1,4-dioxane and/or using incineration to dispose of the 1,4-dioxane wastewater. Incineration of wastewater has an efficiency of 90-98% for 1,4-dioxane[78]. Further

[73] (a) Chemical & Engineering News (2020). 1,4-Dioxane: Another forever chemical plagues drinking-water utilities. Available at: https://cen.acs.org/environment/pollution/14-Dioxane-Another-forever-chemical/98/i43 (b) US EPA (2023). Draft Supplement to the Risk Evaluation for 1,4-Dioxane. Available from: https://www.epa.gov/system/files/documents/2023-07/1.%20Draft%20Supplement%20to%20the%20Risk%20Evaluation%20for%2014-Dioxane%20-%20public%20release%20-%20hero%20-%20July%202023.pdf

[74] CESIO (2024) Applications. Available from: https://www.cesio.eu/index.php/applications

[75] Doherty A-C, Lee C-S, Meng Q, Sakano Y, Noble AE, Grant KA, Esposito A, Gobler CK and Venkatesan AK (2023). Contribution of household and personal care products to 1,4-dioxane contamination of drinking water. Current Opinion in Environmental Science & Health, 31:100414.

[76] Ricardo (2024). CESIO Response to the UBA Questionnaire. Final Report.

[77] Karges U, de Boer S, Vogel AL, Püttmann W. Implementation of initial emission mitigation measures for 1,4-dioxane in Germany: Are they taking effect? Sci Total Environ. 2022 Feb 1;806(Pt 4):150701

[78] Rüdel H, Körner W, Letzel, T. et al (2020) Persistent, mobile and toxic substances in the environment: a spotlight on current research and regulatory activities. Environ Sci Eur 32, 5. Available from: https://doi.org/10.1186/s12302-019-0286-x

information on these technologies is provided in Appendix 5. It should be noted that these treatment techniques can be energy intensive, this is further discussed in section 4.2.4.

Within the two restriction scenarios, there are no proposed limits on the concentrations of 1,4-dioxane in wastewater. A limit value of 5 ppm of 1,4-dioxane is assumed to be feasible from stakeholders in the surfactant value chain. It is estimated that the stripping of 1,4-dioxane in surfactants would increase and subsequently the treatment of this wastewater by technologies such as AOP or incineration would increase. It is assumed that there would be benefits to waste production and treatment where a large number of Member States require treatment of the 1,4-dioxane containing wastewater, as despite an increase in contaminated wastewater from stripping, there would be greater uptake of wastewater treatment technologies and increased treatment of 1,4-dioxane wastewater.

The decrease in 1,4-dioxane levels in the manufactured surfactants are also assumed to have a positive impact on the waste produced by the downstream user sectors as there will be reductions in emissions of 1,4-dioxane to wastewater (as discussed in section 4.2.2.1) from the use of surfactants, such as for 'down the drain' applications.

In summary, there are expected to be positive impacts for the restriction scenarios for wastewater if subsequently treated to destroy the 1,4-dioxane, with a greater impact expected for RS1. For manufacturers, there is expected to be limited impact as the volumes of wastewater would not change. It is assumed that for manufacturers of surfactants the stripping of 1,4-dioxane from surfactants may increase as discussed in section 4.1.1.2 resulting in increased waste production and treatment of wastewater containing 1,4-dioxane. However, this potential increased use of treatment processes are energy intensive, reducing the overall positive impact. For downstream user sectors, there is expected to be a decrease in the 1,4-dioxane concentration levels in the products (from the reduced levels in the used surfactants), thus resulting in a decrease of 1,4-dioxane emissions in 'down the drain' applications, However, it is not possible to quantify the potential changes in wastewater quantities.

4.2.3.2 Implications on a wastewater limit of 1,4-dioxane

In the call for evidence, no limit values for 1,4-dioxane in wastewater were proposed[79]. As part of the survey, respondents were asked about the feasibility of a limit value of 0.005 ppm 1,4-dioxane in wastewater[80]. From the information received, this limit value is generally not achievable for manufacturers, with insufficient information received for the downstream sectors.

In the follow up UBA survey, this wastewater value of 0.005 ppm would not be feasible for manufacturers[81]. The consensus amongst manufacturers is that a limit value of 5 ppm 1,4-dioxane is a technically achievable level for treated wastewater concentrations of 1,4-dioxane using conventional treatment processes such as those discussed above.

Based on this technically feasible limit value, it is expected that there would be positive impacts for RS2 as the levels of 1,4-dioxane in wastewater would be 5 ppm or below. On the other hand, there would be impacts on energy from the increased use of stripping of 1,4-dioxane and the subsequent treatment of the produced wastewater, This is discussed in section 4.2.4.

4.2.4 Effects on use of resources (energy)

As discussed in Section 4.2.3 under both RS1 and RS2 it is likely that additional processes would be used by surfactant manufacturers to reduce the 1,4-dioxane levels in their surfactants, with the produced wastewater containing 1,4-dioxane also requiring treatment. The manufacturing of surfactants on its own (without 1,4-dioxane removal) is an energy-intensive process under the baseline[82].

Firstly, it has been indicated from consultation that manufacturers are likely to use 1,4-dioxane stripping technologies to reduce the 1,4-dioxane content in surfactants. Briefly, this process involves the use of vacuum to remove 1,4-dioxane under temperature and pressure which is discussed further in Appendix 5. Consequently, this process requires extra energy consumption for surfactant manufacturers. From

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[79] ECHA (2023). Call for Evidence and Information on 1,4-dioxane as well as Substances and Mixtures Containing 1,4-dioxane as a Constituent or an Impurity. Available from: https://echa.europa.eu/documents/10162/5d05d8e1-27bb-74c5-b102-d5b903aa7e13

[80] This was added to the survey following a suggestion from BAuA dated 26th September 2023

[81] Ricardo (2024). CESIO Response to the UBA Questionnaire. Final Report.

[82] Ricardo analysis based on stakeholder feedback

consultation with surfactant manufacturers, under RS1, the energy consumption from stripping processes of the surfactant active matter could be 40-50% greater than that of RS2, which also requires extra energy consumption. Secondly, the wastewater containing 1,4-dioxane from the stripping process requires treatment. This wastewater could be treated by various methods, such as advanced oxidation processes (i.e. the use of UV and Fenton's reagent) which is further discussed in Appendix 5. Treating wastewater with advanced oxidation processes for the removal of 1,4-dioxane can result in a substantial increase in the energy consumption of up to double that compared to a baseline scenario (i.e. no removal).

Under both of the restriction scenarios, the increased energy consumption from 1,4-dioxane stripping and the subsequent wastewater treatment could negatively impact initiatives such as the EU Green Deal[83]. Key aims of the Green Deal for energy include the reduction of net greenhouse gas emissions by 55% by 2030, to be carbon-neutral by 2050 and to increase the energy efficiency and eco-design of products. The energy intensive processes for reducing the levels of 1,4-dioxane in surfactants will result in a decrease in the energy efficiency of the sector. The increased energy consumption by surfactant manufacturers can also have negative impacts on Member State's national long-term strategies for meeting both the Paris Agreement and Energy Union objectives[84].

In conclusion, for both RS1 and RS2 it is assumed that there will be negative impacts for the use of resources (energy) resulting from the extra energy required for the stripping of 1,4-dioxane from surfactants and the treatment of the produced wastewater. The degree of impact is assumed to be greater for RS1 as the affected portfolio for manufacturers is in the range of 50%-100% compared to 15-50% under RS2.

4.2.5 Overall environmental impacts

In summary, it is most likely that there will be net positive impacts on the environment that could result from the adoption of either of the restriction scenarios.

On one hand, the **reduction of emissions of 1,4-dioxane from surfactants could have environmental benefits on the quality of water**. Under both restriction scenarios, there will be a reduction in emissions for both surfactant manufacturers and the downstream user sectors, with a greater degree of emission reductions under restriction scenario 1. This would also lead to a positive impact on the waste production and treatment as the potential 1,4-dioxane content in surfactants will be reduced and treated by manufacturers with less 1,4-dioxane potentially going 'down the drain' from downstream uses.

On the other hand, there is likely to be negative impacts on energy resources. The evidence suggests that that the stripping of 1,4-dioxane from surfactants (which is the preferred response to the scenarios) and the subsequent treatment of wastewater containing this 1,4-dioxane are energy intensive processes.

The environmental impact conclusions are summarised qualitatively in the Table below, using the scoring framework described in Section 2 and, in more detail, in the Annexes.

Table 4-23 Overview of the environmental impact assessment for each restriction scenario against the baseline

Environmental impacts	Restriction Scenario 1 (against baseline)	Restriction Scenario 2 (against baseline)
Environmental quality and resources (water)	+2.0	+1.0
Waste production and treatment	+1.0	+0.5
Use of resources (energy)	-2.0	-1.0
Overall environmental impact	**+0.5**	**+0.2**

Source: Ricardo analysis based on the evidence presented in this Study.

[83] European Commission (n.d.). The European Green Deal. Available from: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en

[84] European Commission (n.d.). National long-term strategies. Available from: https://commission.europa.eu/energy-climate-change-environment/implementation-eu-countries/energy-and-climate-governance-and-reporting/national-long-term-strategies_en

5. COMPARISON OF THE RESTRICTION SCENARIOS

This section outlines the overall conclusions that are supported by the Study, building on the latest guidelines and available evidence; and summarises an assessment of cost-effectiveness and the qualitative balance of impacts, costs and benefits cross each of the two restriction scenarios.

5.1 COMPARATIVE ANALYSIS AND RESULTS

5.1.1 Cost-effectiveness analysis

. 1,4-dioxane has been concluded to be very persistent in the environment[85]. Persistent substances raise concerns due to their potential to remain and accumulate over long periods of time in environmental compartments, which could lead to negative effects on humans and the environment over time. However, 1) it is difficult to predict the scale of any of these potential impacts using current testing and modelling approaches, and 2) current methods do not allow for the estimation of a “safe” concentration or the identification of when such a concentration would be breached. This means that, at this stage, the quantification of risks associated with 1,4-dioxane emissions is not possible.

1,4-dioxane is toxic to aquatic organisms at high concentrations which are unlikely to be reached in the natural environment. However, insufficient evidence is available for the quantification and valuation of any potential benefits from reduced emissions via standard impact pathway approaches.

The SEAC has established guidance on how to use cost-effectiveness methodologies to compare the compliance costs that the European society are ‘willing to pay’ to reduce emissions of persistent substances, based on historical evidence of adopted chemical restrictions[86]. The Table below presents the costs per kilogram of chemical release reductions for recent REACH restrictions.

Table 5-1 Cost-effectiveness of recent REACH restrictions on chemicals.

Chemical	€/kg of emissions reductions
Lead in shot in wetlands	9 €/kg
Lead in PVC (under decision-making)	308 €/kg
D4, D5 in wash-off cosmetics	415 €/kg
DecaBDE	464 €/kg
Phenylmercury compounds	649 €/kg
PFOA-related substances	734 €/kg
PFOA	1,649 €/kg

Source: Committee for Risk Assessment (RAC), Committee for Socio-Economic Analysis (SEAC) (2019). Opinion on an Annex XV dossier proposing restrictions on Octamethylcyclotetrasiloxane (D4); Decamethylcyclopentasiloxane (D5) and Dodecamethylcyclohexasiloxane (D6).

These estimates can be used as “benchmarks” for comparison against the abatement costs estimated for the restriction scenarios under assessment.

For this comparison, we have developed a statistic based on the NPV of adjustment (or compliance) costs previously estimated, divided by the total 1,4-dioxane emission reductions estimated for the period of analysis. These estimates are uncertain and presented in the Table overleaf, including a mid-point, lower and upper bound estimate.

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[85] ECHA (2024). PBT assessment list 1,4-dioxane. Available from: https://echa.europa.eu/pbt/-/dislist/details/0b0236e183691f6e

[86] ECHA (2023). Evaluation of restriction reports and applications for authorisation for persistent substances in SEAC. Available from: af4a7207-f7ad-4ef3-ac68-685f70ab2db3 (europa.eu)

Table 5-2 Cost-effectiveness of the restriction scenarios

PBT/vPvB chemical	€/kg of emission reductions	
	RS1	RS2
1,4-dioxane (mid-point, lower and upper bounds)	117,000 €/kg (46,000 – 158,000 €/kg)	50,000 €/kg (33,000 – 80,000 €/kg)

Source: Ricardo analysis based on the evidence presented in this Study and expert input.

In summary, this means that under RS1, the emissions' abatement costs are around €117,000 per kg and could range from €46,000 per kg to €158,000 per kg of 1,4-dioxane emissions reductions. Under RS2, the abatement costs would be lower at around €50,000 per kg and could range from €33,000 per kg to €80,000 per kg of 1,4-dioxane emissions reductions. These ranges reflect uncertainty in: i) the potential emissions of 1,4-dioxane that might result from the portfolio of products in the surfactants value chain due to the limited data available regarding the content of 1,4-dioxane in the upstream and downstream sectors; and ii) the potential costs that might be incurred by industry to transform their operations. The Appendices provide a more detailed description of the methodology.

The abatement costs under the restriction scenarios are thus:

- At least 30 times higher than those estimated for PFOA (i.e., the 'willingness to pay' to reduce emissions of PFOA in the EEA). The restriction of PFOA included all relevant salts resulting in a group of widely used substances with risks that are difficult to estimate and assess, whereas 1,4-dioxane is only being used as a solvent or is an impurity that can be formed during manufacturing with potentially lower environmental risks based on the available evidence (refer to Section 3.1.4for an assessment of the ecological toxicity of 1,4-dioxane).
- More than 50 times[87] higher than the costs per emissions reductions estimated for any non-PFOA persistent chemicals presented in Table 5-1.

Therefore, it is considered that the restriction scenarios might not be cost-effective, and it is more likely that the costs are higher than what the EEA has recently been willing to pay to manage risks.

These results have fed into the analysis of the balance of impacts, costs and benefits below.

5.1.2 Balance of economic and environmental impacts, costs and benefits

The outputs of the SEA from Section 5.1.1 resulted in a set of comparable ratings for the restriction scenarios against the baseline, across the broad economic and environmental impact categories and overall costs and benefits. These outputs are the result of analysis of the evidence collected, and analysis performed and captured in earlier sections of this Study.

Table 5-3 below reiterates the colour-coding used to summarise the qualitative assessment of impacts referring to the direction (positive or negative) and magnitude (small or large) of any expected impacts. A more detailed description of the qualitative assessment methodology and other analytical methods employed in this report can be found in the Appendices.

Table 5-3 Scoring and colour coding used to present the assessment conclusions.

Strongly negative	Negative	Weakly negative	No or limited impact	Weakly positive	Positive	Strongly positive	Unclear
-5	-3	-1	0	+1	+3	+5	N/A

Table 5-4 below summarises the aggregated economic and environmental impacts by restriction scenario from a societal perspective, covering all pertinent stakeholders: industry (large and smaller businesses), citizens

[87] This is the lowest and thus most conservative comparative ratio, as it is based on the ratio of the lowest cost-effectiveness estimate for 1,4-dioxane (lower bound of 33,000 €/kg under RS2) and the cost-effectiveness ratio of Phenylmercury compounds, which is the highest of the non-PFOA substances in Table 5-1.

and workers, third countries. These ratings have been aggregated from an analysis across eight economic and environmental impact categories which were shortlisted for in-depth assessment as a result of a screening exercise summarised in Appendix 1.

Table 5-4 Overview of the economic and environmental impacts for each restriction scenario.

Restriction Scenario	Economic impacts	Environmental impacts
Restriction Scenario 1 (against baseline)	-3.5	+0.5
Restriction Scenario 2 (against baseline)	-1.5	+0.2

Source: Ricardo analysis based on the evidence presented in this Study.

In addition, the balance of costs and benefits to EU society in scope of this SEA provides additional insights into the merits of each restriction scenario. The impacts across the broad categories have, therefore, been grouped into economic and environmental costs and benefits for a relatively more straightforward comparison of the options. Table 5-5 brings together the aggregated economic and environmental impacts by restriction scenario from a societal perspective, covering all pertinent stakeholders: manufacturers and importers of surfactants, downstream user sectors in scope, EU-27 citizens and the EU-27 environment. Similar colour-coding is used, again, to refer to the direction (positive or negative) and size (small or large) of any expected impacts.

Table 5-5 Economic and environmental costs and benefits of the restriction scenarios against the baseline*

Restriction Scenario	Costs	Benefits	Benefit: Cost Ratio
Restriction Scenario 1 (against baseline)	-5.0	+2.0	0.5
Restriction Scenario 2 (against baseline)	-2.0	+1.0	0.5

*Source: Ricardo analysis based on the evidence presented in this Study.**Rounded figures*

In conclusion, the estimated benefits under the restriction scenarios appear to be lower, in scale, than the costs. However, this excludes any consideration of social and human health impacts. The assessments presented in the preceding sections of this report have highlighted a range of costs that could be incurred across economic dimensions, and some costs concerning even environmental dimensions, such as energy resources. In addition, some potential benefits have been identified, associated with innovation and research although these are very uncertain (economic); and water quality and resources and waste production and treatment (environmental). These benefits are considered to be of a lower scale, when compared to the economic costs, which is represented by a benefit-to-cost ratio (BCR) lower than 1 across all restriction scenarios. Moreover, the estimated emissions' abatement costs surpass those of other recent restrictions, as noted earlier. This presents additional and even more conclusive evidence against the adoption of the restriction scenarios considered in this Study.

5.2 UNCERTAINTIES AND SENSITIVITY ANALYSIS

As is inherent with all *ex-ante* assessments, there are uncertainties and limitations to the analysis. In the case of this assessment, these are linked to the uncertainty of the proposed REACH restriction, the availability of quality data, and the relatively high level of complexity for how these restriction scenarios may affect the surfactants value chain in the EU-27 (including manufacturers and importers of surfactants and downstream user industries), and the environment.

Firstly, at the time of writing, the REACH restriction proposal on 1,4-dioxane as an impurity has not been released and the final restriction remains uncertain and under development. This means that the restriction details are not yet clear and assumptions have been required. Assumptions have been quality assured and verified by CESIO so that they reflect the current debate as much as possible. As discussions are ongoing, the assumptions made in this assessment may not accurately reflect the regulatory changes that enter into force. However, the assessment carried out and its outputs are highly dependent on these assumptions and, therefore, reflect the same level of uncertainty.

Secondly, the available data has limitations. There is limited historical evidence of relevance, given that the restriction scenarios considered for future implementation go over and above any other policies implemented in the EU-27 and internationally related to 1,4-dioxane. It has been, therefore, necessary to rely on a consultation of businesses to gather evidence as to the potential actions they may take as a response to a REACH restriction 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 a REACH restriction on 1,4-dioxane may affect their operations. The sample is not statistically representative but effectively captures a large proportion of the surfactants market production (>80% of baseline sales turnover).

More limited coverage was achieved of the overall downstream sectors in scope (~40% of baseline sales turnover), with significant variation based on the specific downstream user sector. In terms of sales turnover, the survey had good coverage of the agrochemical products and applications market (~70%) and detergents and cleaning products market (>50%), but limited coverage of the cosmetics and personal care products market (30%), the paints, coatings, adhesives, elastomers, and printing inks market (30%) and the chemical products for textiles and leather sector market (5%). Nevertheless, the estimates presented in the survey were considered to offer a reasonable basis to develop assumptions, based on expert inputs and the evidence. Thus, this evidence has been used to illustrate the potential scale of the effects that the restriction scenarios may have across very diverse and complex downstream sectors that use surfactants with 1,4-dioxane as an impurity.

Moreover, the sample also comprises a disproportionate number of large firms. This is not deemed a significant issue since the majority of the manufacturing output is generated by large firms, and a comparative analysis between SME versus large enterprise impacts was not possible due to sample limitations.

Thirdly, the known uncertainties were quantified as part of the ranges presented in the main results tables and diagrams. These present possible low and upper bound effects, and select a medium or central estimate that, based on the available evidence, appears to be most likely. There is variation in the responses to the stakeholder consultation regarding the levels of 1,4-dioxane associated with surfactant products across some segments of the value chain and the ability of the businesses to substitute and/or adjust these products. Thus, it is acknowledged that any point along the ranges presented in this Study offer a reasonable basis for conclusion, even though it is considered that the 'medium' estimates are more likely.

The sensitivity of the conclusions to any point along the ranges were considered, and these remain unchanged, especially concerning the cost-effectiveness conclusions, which offer an opportunity to compare the extent to which reducing environmental releases might be more or less costly, when compared to relevant benchmarks (or adopted restrictions).

Fourthly, the policies under consideration will affect the EU-27 surfactants value chain and the environment in multiple and complex ways. In this context, two key impact drivers on businesses were considered: direct and indirect reductions in the manufacture, import and use of surfactants containing 1,4-dioxane; and additional compliance burden, thus potentially affecting the economic viability of certain operations in the EU-27. The extent to which these impacts affect sub-sectors and businesses, and how these businesses may respond, will vary, including whether or not business will discontinue, adjust 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.

Key economic impacts, such as increasing compliance costs and possible reductions in GVA of the surfactants value chain in scope, are sensitive to the assumptions of the affected portfolio and substitution rates of the affected portfolio of products (in terms of sales turnover). Sensitivity analysis was considered and performed to examine how these core assumptions regarding the affected portfolio and level of substitution may affect the key estimate of potential net product withdrawal, driven the rest of the economic impacts estimated in this study. Ranges across the main assumptions (affected portfolio and substitution) were already included in the main body of this Study (refer to Sections 4.1.1.3). Similar ranges have also been included for the net employment withdrawal in the main body of the Study (refer to Section 4.1.4.1). The overall conclusions remain unaffected under the possible yet unlikely low and high scenarios.

Fifthly, **for environmental impacts, there are considerable data limitations surrounding the levels of 1,4-dioxane associated with products in each segment of the value chain and the resulting emissions of 1,4-dioxane**, **and levels of 1,4-dioxane in ground and surface water,** making it very difficult to estimate the environmental costs and benefits. As a result, emission reductions have been derived based on data provided by CESIO and responses from the stakeholder consultation, estimating a likely medium scenario alongside unlikely but possible 'low' and 'high' impact scenarios which are presented in the main body of this Study (refer to Sections 3.1.4 and 4.2.2.1). The overall conclusions remain unaffected under the possible yet unlikely low and high scenarios.

Moreover, there are also a number of known unknowns, such as how technological progress may affect the surfactants value chain as well as the wider society and whether and how this would interact with the impacts of a REACH restriction. Further, international trade and competitiveness are likely to affect the EU surfactants industry, but these effects are not considered in depth primarily due to limitations in the evidence available. These are further sources of uncertainty.

In summary, it is acknowledged that there are a range of uncertainties associated with the evidence and assumptions developed for this Study. However, the conclusions reached in the following section based upon the 'medium' scenario estimates do not appear to be sensitive to the possible yet unlikely low and high scenario estimates.

5.3 CONCLUSIONS

The outputs of this assessment and the comparison of the impacts between the baseline ('do nothing') scenario and the two restriction scenarios suggest that:

- Under both of the restriction scenarios, the abatement costs for reducing the emissions of 1,4-dioxane in surfactants are at least 30 times higher than those of PFOA, which offer a benchmark of the current 'willingness to pay' to reduce the emissions of persistent substances to the environment in the EU.
- The costs that might result from the adoption of the restriction scenarios include adjustment costs (or increasing costs of production), a reduction in industrial activity in the EU, worsened competitiveness, reductions in employment and negative impacts on consumers. Benefits that might result from the restriction scenarios include positive implications potentially on innovation and research albeit very uncertain; and water quality and resources and waste production and treatment.
- The economic and environmental benefits are assessed to be of lower scale than the costs under both restriction scenario, with an estimated benefit: cost ratio lower than 1.

These findings do not support the adoption of either of the restriction scenarios considered in this Study and suggest that other more cost-effective measures should be explored and defined to achieve the EU's objectives.

APPENDICES

APPENDIX 1 METHODOLOGY

A1.1 OVERVIEW

This Appendix provides additional information on the methodology employed in this Study for assessing the impacts from the implementation of the two restriction scenarios. The following aspects are elaborated further on:

- Mapping of impacts
- Screening of impacts
- Baseline estimation
- Assessment of the impacts
- Restriction scenario comparison

A1.2 MAPPING OF IMPACTS

The potential impacts of each restriction measure or groups of similar measures have been mapped employing impact pathway and theory of change approaches. These potential impacts have been being categorised in line with the Better Regulation Guidelines Tools #18 (identification of impacts) and #56 (typology of costs and benefits)[88]. This mapping exercise produced a longlist of 23 potential impacts from the adoption of the restriction scenarios.

[88] European Commission (2021) Better Regulation Toolbox. Available from: https://commission.europa.eu/law/law-making-process/planning-and-proposing-law/better-regulation/better-regulation-guidelines-and-toolbox/better-regulation-toolbox_en#relatedlinks

Table _A 1 Mapping of impacts

#	Specific impact category	Primary broad nature of impact	Affected parties	Relation with underlying initiative	Frequency	Likelihood
1	i. Industrial activity (e.g. withdrawal of substances, developing substitutes, adjustments, adapting production processes, cost avoidance through reduction in sick leave, etc.)	Economic	Enterprises	Both	One-off and recurring	High
2	ii. Administrative burdens on businesses (e.g., training staff, administrative adjustments to new provisions, etc.)	Economic	Enterprises	Direct	One-off	High
3	iv. Innovation and research (e.g. effects on research and development, new production methods, alternatives, technologies for removing 1,4-dioxane, etc.)	Economic	Enterprises	Indirect	One-off	High
4	v. Sectoral competitiveness and trade (e.g. costs of doing business, capacity to innovate, market share impacts, etc.)	Economic	Enterprises	Indirect	One-off and recurring	Medium
5	vi. Functioning of the internal market and competition (e.g. free movement of goods and services, reduction in consumer choice, etc.)	Economic	All parties	Indirect	One-off and recurring	Medium
6	vii. Public authorities and budgets (e.g. changes to the administrative activity carried out by public authorities from increased requirements as well as the alignment and potential synergies with other legislation, financial and human resources, etc.)	Economic	Public authorities	Direct	One-off	High
7	viii. Sustainable consumption and production (e.g. effects on the relative prices of environmentally friendly versus unfriendly products and the transition to safe and sustainable chemicals)	Economic	All stakeholders	Indirect	One-off and recurring	Medium

#	Specific impact category	Primary broad nature of impact	Affected parties	Relation with underlying initiative	Frequency	Likelihood
8	ix. Efficient use of resources (e.g. effects on the availability and use of resources such as fish, wood, etc.)	Economic	All stakeholders	Indirect	One-off and recurring	Low
9	x. Third countries, developing countries, and international relations (e.g. effects on adjustment costs in developing countries or goods and services produced or consumed, etc.	Economic	Global citizens	Both	One-off and recurring	High
10	xi. Capital movements; financial markets; stability of the euro	Economic	Consumers	Indirect	One-off and recurring	High
11	xii. Consumers and households (e.g. effects on consumers' ability to access goods and services, their prices, quality, etc.)	Economic	Consumers	Indirect	One-off and recurring	Medium
12	xvi. Employment (e.g. new jobs created or lost, etc.)	Economic	EU residents	Both	Recurring	Medium
13	xxvi Climate	Environmental	All stakeholders	Indirect	Recurring	Medium
14	xxvii Quality of natural resources (water)	Environmental	All stakeholders	Direct	Recurring	High
15	xxvii Quality of natural resources (soil)	Environmental	All stakeholders	Direct	Recurring	Low
16	xxvii Quality of natural resources (air)	Environmental	All stakeholders	Direct	Recurring	Low
17	xxviii Biodiversity, including flora, fauna, ecosystems and landscapes	Environmental	All stakeholders	Direct	Recurring	Medium
18	xxix. Animal welfare (e.g., impact on the health of animals from testing, impact on outdoor animals from environmental exposure, etc.)	Environmental	All stakeholders	Indirect	Recurring	Low

#	Specific impact category	Primary broad nature of impact	Affected parties	Relation with underlying initiative	Frequency	Likelihood
19	xxx. Waste production, generation, and recycling	Environmental	All stakeholders	Direct	Recurring	High
20	xxxii Efficient use of resources (renewable and non-renewable)	Environmental	All stakeholders	Indirect	Recurring	High
21	xxxiii Land use	Environmental	All stakeholders	Indirect	Recurring	Low
22	xxxiv The likelihood or scale of environmental risk	Environmental	All stakeholders	Indirect	Recurring	Low
23	xxxv Transport and the use of energy	Environmental	All stakeholders	Indirect	Recurring	Low

A1.3 SCREENING OF IMPACTS

The affected stakeholders for each of these specific impact categories, the underlying relationships with the initiative and the frequency and certainty of impact were also identified. Based on this, the available evidence and expert opinion, a screening exercise was performed to identify the most significant impacts for in-depth assessment across all restriction scenarios, to enable a proportionate approach for the assessment of impacts.

The screening exercise has been primarily qualitative, based on the evidence available at early stages of the project and reviewed periodically, and following the Better Regulation Guidelines[89]. Each specific impact category has been scored across the following dimensions using different qualitative scales: the expected magnitude of potential impact (-5 - +5 score, where the sign reflects the direction of impact, whilst the number reflects the scale of impact); the likelihood of impact (0 - +3 score, where a higher number reflects a higher likelihood); and the importance of impact against EC's objectives (0 - +3 score, where a higher number reflects a higher importance). The below Table provides more detail.

Table _A 2 Impact screening approach

Criteria	Guidance
1 – Affected stakeholders	Select primary stakeholders affected by the impact of the/group of measure/s. • All stakeholders • Public authorities • All businesses • Businesses: Manufacturers and importers • Businesses: Downstream user sectors • EU citizens • (Global citizens)
2.1 – Absolute impact: magnitude	• Select qualitatively per type of impact: • None (0) • Low (1) • Low/Medium (2) • Medium (3) • Medium/high (4) • High (5) These are considered as follows: • High: Widespread and deep effects on the EU's economic wellbeing, whether affecting the majority of EU residents, businesses and other actors or some of these actors in a very significant way • Medium: Substantial/ transformational impact on a small group of stakeholders or marginal/ small impact on a wide range of stakeholders across the EU. • Low: Marginal or small impact on a small group of stakeholders or limited impact on a wide range of stakeholders. • None: No impact expected with a high level of certainty.
2.2 – Absolute impact: likelihood	Select qualitatively per type of impact: • None (0) • Low likelihood (1) • Medium likelihood (2) • High likelihood (3) These are considered as follows: • High: Evidence points to the impact materialising in the scale identified

[89] European Commission (2021) Better Regulation Toolbox. Available from: https://commission.europa.eu/law/law-making-process/planning-and-proposing-law/better-regulation/better-regulation-guidelines-and-toolbox/better-regulation-toolbox_en#relatedlinks

Criteria	Guidance
	with a high level of certainty (e.g., >75% chance) • Medium: Evidence is unclear that the impact would materialise in the scale identified although it is likely (e.g., ~ 50% chance) • Low: Evidence is limited, and the impact may not materialise at all or is unlikely to materialise in the scale identified (e.g., <25% chance). • Note: Certain (or almost certain) that the impact identified will not materialise.
2.3 – Absolute impact: direction	Select qualitatively per type of impact: • Positive • Negative • None • Unclear Note: Positive should contribute towards EU objectives, efficiency, productivity, etc. Whereas negatives do not contribute to EU objectives, increase costs or negatively affect business opportunities.
2.4 – Relative impact: likelihood	Select qualitatively per type of impact: • Low likelihood (1) • Medium likelihood (2) • High likelihood (3)
3.1 – Relative impact: Disproportionately affected stakeholder group	Select the stakeholder that may be affected disproportionately if any: [From list of stakeholders] Note: These should highlight the group of stakeholders that will be significantly affected even if the overall impact is low.
3.2 – Relative impact: likelihood	Select qualitatively per type of impact: • Low likelihood (1) • Medium likelihood (2) • High likelihood (3)
3.3 – Relative impact: direction	Select qualitatively per type of impact: • Positive • Negative • None • Unclear
4 – Relationship	Select qualitatively per type of impact: • Direct • Indirect • Both
5 – Relevance	Select qualitatively per type of impact: • None • Low • Medium • High These are considered as follows: • High: all of the impact identified is intended and aligned with the objectives. • Medium: a major part of the impact identified is intended and somewhat aligned with the objectives. • Low: a small part of the impact identified against a given category is intended and somewhat aligned with the objectives. • None: the impact identified against a given category is not intended.

In general, an impact category with medium level of negative or positive impact (-2/+2 score or a higher scale negative or positive), with a medium or higher level of likelihood and would be selected for more in-depth assessment (e.g., the conduct of business is very likely to be affected significantly)). Secondly, expert judgement was used to develop a shortlist for in-depth assessment. The shortlist comprises of the following eight impact categories. A more detailed assessment underpinning this list is presented in the following Table.

- Industrial activity
- Innovation and research
- Global competitiveness and trade
- Consumers and households
- Employment
- Quality of natural resources (water)
- Waste production, generation, and recycling
- Efficient use of resources (energy)

Table _A 3 Screening of impacts

#	Specific impact category	Primary broad nature of impact	Affected parties	Relevance for specific parties	**Magnitude of potential impact [-5,5]**	Likelihood	**Importance against EU objectives (0,3)**	**Most significant (Yes/No)**
1	i. Industrial activity (e.g. withdrawal of substances, developing substitutes, adjustments, adapting production processes, cost avoidance through reduction in sick leave, etc.)	Economic	Enterprises	n/a	-3	3	2	Yes
2	ii. Administrative burdens on businesses (e.g., training staff, administrative adjustments to new provisions, etc.)	Economic	Enterprises	n/a	-2	1	2	No
3	iv. Innovation and research (e.g. effects on research and development, new production methods, alternatives, technologies for removing 1,4-dioxane, etc.)	Economic	Enterprises	n/a	-3	3	2	Yes
4	v. Sectoral competitiveness and trade (e.g. costs of doing business, capacity to innovate, market share impacts, etc.)	Economic	Enterprises	n/a	-3	3	2	Yes
5	vi. Functioning of the internal market and competition (e.g. free movement of goods and services, reduction in consumer choice, etc.)	Economic	All parties	n/a	-2	2	1	No
6	vii. Public authorities and budgets (e.g. changes to the administrative activity carried out by public authorities from increased requirements as well as the alignment and potential synergies with other legislation, financial and human resources, etc.)	Economic	Public authorities	n/a	-1	2	1	No
7	viii. Sustainable consumption and production (e.g. effects on the relative prices of environmentally friendly versus unfriendly	Economic	All stakeholders	n/a	0	3	0	No

#	Specific impact category	Primary broad nature of impact	Affected parties	Relevance for specific parties	**Magnitude of potential impact [-5,5]**	Likelihood	**Importance against EU objectives (0,3)**	**Most significant (Yes/No)**
	products and the transition to safe and sustainable chemicals)							
8	ix. Efficient use of resources (e.g. effects on the availability and use of resources such as fish, wood, etc.)	Economic	All stakeholders	n/a	-1	2	2	No
9	x. Third countries, developing countries, and international relations (e.g. effects on adjustment costs in developing countries or goods and services produced or consumed, etc.	Economic	Global citizens	n/a	0	1	1	No
10	xi. Capital movements; financial markets; stability of the euro	Economic	Consumers	n/a	-2	2	2	No
11	xii. Consumers and households (e.g. effects on consumers' ability to access goods and services, their prices, quality, etc.)	Economic	Consumers	n/a	-3	3	1	Yes
12	xvi. Employment (e.g. new jobs created or lost, etc.)	Economic	EU residents	n/a	-4	2	2	Yes
13	xxvi Climate	Environmental	All stakeholders	n/a	0	0	3	No
14	xxvii Quality of natural resources (water)	Environmental	All stakeholders	n/a	3	3	3	Yes
15	xxvii Quality of natural resources (soil)	Environmental	All stakeholders	n/a	1	1	3	No
16	xxvii Quality of natural resources (air)	Environmental	All stakeholders	n/a	1	2	3	No
17	xxviii Biodiversity, including flora, fauna, ecosystems and landscapes	Environmental	All stakeholders	n/a	1	1	3	No

#	Specific impact category	Primary broad nature of impact	Affected parties	Relevance for specific parties	**Magnitude of potential impact [-5,5]**	Likelihood	**Importance against EU objectives (0,3)**	**Most significant (Yes/No)**
18	xxix. Animal welfare (e.g., impact on the health of animals from testing, impact on outdoor animals from environmental exposure, etc.)	Environmental	All stakeholders	n/a	0	0	3	No
19	xxx. Waste production, generation, and recycling	Environmental	All stakeholders	n/a	3	2	3	Yes
20	xxxii Efficient use of resources (renewable and non-renewable)	Environmental	All stakeholders	n/a	-4	2	3	Yes
21	xxxiii Land use	Environmental	All stakeholders	n/a	0	0	0	No
22	xxxiv The likelihood or scale of environmental risk	Environmental	All stakeholders	n/a	-1	1	1	No
23	xxxv Transport and the use of energy	Environmental	All stakeholders	n/a	0	0	0	No

A1.4 DEFINE AND CHARACTERISE THE BASELINE SCENARIO

This Study defined how the different business figures for manufacturers, importers and selected downstream users in the EU-27 for EO-based surfactants that contain 1,4-dioxane as an impurity would likely evolve in the absence of a REACH restriction. This includes:

- Defining the 'do nothing' or baseline scenario, that is, what the manufacturers, importers and selected downstream users in the EU-27 would look like in the absence of the proposed REACH restriction;
- Identifying key economic and sectoral indicators that could be used to characterise the potential evolution of manufacturers, importers and selected downstream users in the EU-27; and
- Quantifying how these indicators would likely evolve up to 2040.

First, policy experts from the study team defined what the 'Do nothing' scenario would look like in terms of legislation. In particular, the study team experts confirmed the existing legislation and the legislative changes that are already expected for implementation over the period. No legislative changes are assumed under the baseline scenario.

Secondly, a quantitative baseline of EO-based surfactant manufacturers and importers and selected downstream user sectors from 2010-2040 has been established, which captures key proxies for the industry's size, costs or expenditures, and the contribution to the EU socio-economy. These proxies include turnover, production, Gross Value Added (GVA), imports, exports, operating and capital expenditures and employment. Historical evidence and data were collected using publicly available sources and the Table below summarises the sources used.

Table _A 4 Indicators and data sources used for the baseline scenario

Indicator	Sources
Turnover	Eurostat Structural Business Statistics
Production value	Eurostat PRODCOM Database
Gross Value added (GVA)	Eurostat Structural Business Statistics
Imports	Eurostat PRODCOM Database
Exports	Eurostat PRODCOM Database
Operating expenditure/Opex	Eurostat Structural Business Statistics
Capital expenditure/Capex	Eurostat Structural Business Statistics
Employment	Eurostat Structural Business Statistics

Accessing the data required a few steps.

Firstly, it was necessary to **define the markets of interest (or in scope)**; that is, map the sectors that pertained to the surfactants production and downstream user industries across these databases. A detailed review as performed of the 'Statistical Classification of Economic Activities' in the European Community or NACE (derived from the French title 'Nomenclature statistique des activités économiques dans la Communauté européenne')[90] classification, which the Structural Business Statistics (SBS) aligns with, to identify the relevant sectors and subsectors. This was complemented by a more detailed review of the 'Production Communautaire' (PRODCOM) database classification, which uses a more granular categorisation of sectors by product. The two classifications are mapped, which allows for database triangulation in many cases. This review identified 11 PRODCOM product category for the upstream segment of the industry) and 153 PRODCOM product categories for the downstream sectors in scope, which were mapped NACE codes (from 2-digit codes all to the way to the 8-digit code structure of PRODCOM classifications). The data collected from stakeholders, including data on the impacts of the three restriction scenarios, was structured and organised in this sector mapping. This mapping is auditable and shareable upon request.

[90] Eurostat (2008). NACE Rev. 2: Statistical classification of economic activities in the European Community. Available at: https://ec.europa.eu/eurostat/documents/3859598/5902521/KS-RA-07-015-EN.PDF.pdf/dd5443f5-b886-40e4-920d-9df03590ff91?t=1414781457000

Secondly, once the ‘markets’ were defined, the **data was accessed**, downloaded and analysed across these codes. Gaps were addressed using triangulation and external sources; and the baseline, historical estimations of the size of these ‘markets’ across indicators were established (2010-2021). Baseline estimations set out a position for how the industry could evolve within the current regulatory framework into the future (i.e., ‘Do Nothing’ scenario). Estimations for 2022-2040 were developed using historical evidence and extrapolating it into the future (especially, looking at the relationship between the industry’s performance and EU-27 GDP). In establishing the historical baseline, the year of 2021 was used as a reference point for the analysis to mitigate any issues, as this is considered a relatively normal operating year that may best represent the long-term market and industry dynamics. This was, therefore, used as a reference point for the stakeholder survey.

These methods were employed for all variables of interest, including production, sales turnover, GVA, operating expenditure, capital expenditure, imports and exports.

A1.5 CONSULT STAKEHOLDERS AND GATHER EVIDENCE OF THE BASELINE AND POTENTIAL IMPACTS

A consultation strategy was developed, including a mapping and prioritisation of CESIO members and stakeholders within CESIO’s network in the selected downstream sectors of interest. Stakeholders were split into two broad groups: 1) Manufacturers and importers of surfactants; 2) Downstream user sectors. Two different surveys were thus designed for each of these groups:

- *Manufacturers and importers of surfactants survey*: consultation aimed to gather evidence of the socio-economic footprint of surfactants markets in the EU-27 and the potential implications of the restriction scenarios.
- *Downstream user survey*: consultation aimed to gather evidence of the socio-economic footprint of these markets, their reliance on surfactant products, and the potential implication of restriction scenarios under consideration across selected downstream user markets.

A four-part, 61 question was designed for manufacturers and importers of EO-based surfactants and a four-part, 50 questions survey designed for downstream users:

- Part 1, gathering data about the respondents such as size and primary activities.
- Part 2, seeking to form the baseline, including of their employment, tonnages of surfactants produced/used, turnover, investments, direct business responses, expenditures, R&D etc.
- Part 3, considering direct business responses and associated costs and benefits (e.g., substitution, product adjustment and/or derogations; investments; expenditures; and employment) over at least 15 years from adoption of the proposed restriction.
- Part 4, gathering information on other impacts such as competitiveness, availability of surfactants and wastewater treatment for 1,4-dioxane.

Finally, the table below summarises the type of data and evidence gathered through the consultation:

Table _A 5 Data and evidence of interest in the survey

Economic data	Environmental evidence
• **Volume and turnover value from:** - manufacturing and placing on the market of surfactants. - downstream products from selected markets which are manufactured and/or part of the affected value chain (i.e., containing surfactants with 1,4-dioxane as an impurity). • International trade by production value, including **exports and imports**. • **Number of employees** across these markets (direct). • **Capital, R&D and operating expenditure** in the baseline.	• **Environmental risks** associated with alternatives to surfactants containing levels of 1,4-dioxane subject to restriction • Evidence or knowledge of **wastewater treatment plants** • **Ability of wastewater treatment plants to remove 1,4-dioxane**

Economic data	Environmental evidence
• **Level of 1,4-dioxane in the portfolio of products** (i.e., the affected portfolio under RS1 and RS2) • **Availability (or not) of alternatives** to products that are affected; and thus, proportion of the affected substances across downstream user sectors that could be substituted or adjusted, and time needed to adopt manufacturing processes to adapt to the new regulatory environment • Performance of alternatives • **One-off and recurring costs** of alternatives/ substitutes • Impact on **global competitiveness** • Impact on **availability of products** • Impact on **industrial, professional and consumer users**	

A1.6 ASSESSMENT OF THE ECONOMIC AND ENVIRONMENTAL IMPACTS OF THE RESTRICTION SCENARIOS

This section details the approach and methodology (quantitative and qualitative) employed for assessing the economic and environmental impacts, costs and benefits for the two restriction scenarios under consideration (see Section 3.2) for the proposed REACH restriction of 1,4-dioxane as an impurity in surfactants.

Quantitative approach

This section outlines the methods used to estimate the economic and environmental impacts. Quantitative analysis, inspired by the Standard Cost and Economic Modelling approaches, was carried out to estimate impacts and costs on businesses, also relevant for the 'One In, One Out' considerations. Insufficient evidence was identified to isolate administrative burden. Adjustment (or compliance) costs were primarily the focus of the analysis.

A three-step methodology was implemented to thoroughly analyse the survey data and extract actionable insights.

- The first step involved deriving raw estimates by aggregating the impacts reported in the survey responses. To ensure a balanced representation of perspectives, these impacts were weighted based on the size of the respondent companies, recognising that larger enterprises may exert a proportionally greater influence on the overall outcome. This approach not only accounted for differences in company scale but also provided a foundation for further analysis.
- Following the calculation of raw estimates, a distributional analysis was performed. This step involved an examination of the distribution of responses to identify any notable patterns, trends, or outliers. The aim of scrutinising the data at a granular level was to uncover nuances. This process enabled us to refine our understanding of the data's intricacies and assess the robustness of the findings from step one.
- The internal analysis was supplemented with external evidence obtained from industry reports and follow-up conversations with key respondents. These external sources served to contextualise our findings within broader industry trends and validate our assumptions. Furthermore, engaging in dialogue with survey participants allowed us to delve deeper into specific responses, gaining valuable qualitative insights that enriched our analysis.

Based on this methodology, key percentage impacts were estimated that were later combined with broader baseline data on the evolution of economic variables to estimate the economic and wider economic impacts of the proposed restrictions. This was done as follows:

- Potential production value losses were estimated by considering the proportion of the portfolio that would be affected, minus the proportion that would be exempted and substituted based on the 'assumptions' developed through analysing the evidence provided by businesses through the targeted consultation. That is, losses estimated are net of any substitution/ market for alternatives. These are applied to the baseline developed for this Study. Mathematically, this can be represented as follows:

$$Turnover\ loss = Turnover * (affected\ portfolio\%) * (1 - substitution\%)$$

Where $affected\ portfolio$ refers to the turnover from EO-based surfactants in the case of upstream markets OR the proportion of the turnover that contains and/or requires EO-based surfactants in the case of downstream markets. The $substitution\ \%$ refers to the proportion of the affected portfolios that could be potentially substituted.

- Potential imports losses were estimated by considering the proportion of the domestic portfolio that would be withdraw, minus the proportion of the imports that would be substituted based on the evidence provided by business through the targeted consultation. That is, losses estimated are net of any substitution/ market for alternatives. These are applied to the baseline developed for this Study.
- Employment is assumed to be affected proportionately to how business operations might be affected, albeit any effects are estimated to be lower based on a relationship established between production and employment from the sample and published studies.
- Capital, operating and R&D expenditures are expected to fall in line with the net business size changes (turnover losses) and increase in line with the additional expenditure required to adjust significant proportions of the business (as well as other administrative and compliance activities). The net effects depend on the size of these two impacts, albeit unit costs of production would be likely to increase in all cases.

These core impacts were presented as annual averages (or annualised over the period of 2026-2040) for a comparison against the baseline. An annualisation exercise was done as follows: The Net Present Value (NPV) of the impacts was estimated over the period 2026-2040, using a real discount rate of 3% in line with the Better Regulation Guidelines. This NPV was annualised so that the equivalent annual value for a given metric would, when discounted over the period, produce a similar/same NPV. Sometimes, these annualised figures are referred to as an average for shorthand, although they are technically slightly different than averages.

Additionally, an Input-Output methodology was employed to estimate the indirect and induced effects of the proposed Restriction options on GVA (~GDP) and employment. The total impact of a policy change on sectoral GVA encompasses three components: direct, indirect and induced effects. The direct effects refer to the immediate effect of the policy change on sectoral production and its value added. The indirect effects pertain to changes in the sector's value chain, which influence the intermediate demand for inputs in other sectors. Finally, the induced effects encompass the broader economic effects resulting from changes in compensation to employees, which consequently affect final demand and overall spending in the economy.

In order to assess the direct effects, a combination of consultations and publicly available data was employed. To estimate the indirect and induced effects, or the ripple effects on the economy resulting from the direct impacts on the manufacturers and importers of EO-based surfactants and downstream use sectors, the Leontief or Input-Output model was utilised. This model, along with its associated matrices of economic activity and interconnections, allows for the estimation of multipliers. These multipliers represent the economic activity generated throughout the supply chain and various sectors as a result of one euro spent in a specific sector.

There are two types of multipliers used in the analysis. Type I multipliers capture the direct and indirect effects, indicating the economic impacts throughout the supply chain. On the other hand, Type II multipliers also include the induced effects, assuming that final consumers do not alter their consumption patterns in response to changes in income. Therefore, Type II multipliers encompass the direct, indirect and induced effects, illustrating the impact throughout the supply chain as well as the effects on the wider economy resulting from changes in employee compensation. Mathematically, the indirect and induced effects are estimated as follows:

$$Indirect\ effect = (Type\ I\ multiplier - 1) * Direct\ effect$$

$$Induced\ effect = (Type\ I\ multiplier - Type\ II\ multiplier) * Direct\ effect$$

For both manufacturers and importers of surfactants and downstream user sectors, Type I and Type II multipliers were assumed to be approximately 2.84 and 3.49, respectively. These assumptions were based on evidence from Eurostat, national statistical databases from various European countries, and expert judgment.

A similar approach was also followed to estimate the indirect and induced effects on employment impacts. For this analysis, the Type I and Type II multipliers for both manufacturers and importers of surfactants and downstream user sectors were assumed to be around 1.96 and 2.82, respectively. These were based on the triangulation of the available evidence on the effects on employment and interlinkages within the value chain of the sectors in scope.

For estimating the environmental impacts of the restriction scenarios, estimates of the affected portfolio of products and business responses to the restriction from the stakeholder consultation were combined with baseline data on the production and usage of surfactants provided by CESIO. This was done as follows:

- The tonnes of surfactants used in each 'downstream user' sector was estimated using the CESIO data on the tonnes of EO surfactant production and surfactant applications across sectors in Western Europe (refer to Figure 3-2). For the surfactants manufacturers, the tonnes of treated wastewater produced was estimated using data from the CESIO UBA survey.
- 'Assumptions' for the average ppm concentrations of 1,4-dioxane in the surfactants and downstream user products were developed by analysing the evidence provided by businesses through the targeted stakeholder consultation (including evidence on the levels of 1,4-dioxane in their products and the percentage of the affected portfolio that could potentially be substituted and/or adjusted under RS1 and RS2). Separate assumptions were developed for the baseline and the two restriction scenarios, with a worst-case assumption that the entire portfolio of products that is substituted and/or adjusted has an average concentration of 1 ppm of 1,4-dioxane under RS1 and 10 ppm of 1,4-dioxane under RS2.
- Emissions attributable to the surfactants and 'downstream user' sectors were estimated by combining the data on usage of surfactants/ wastewater production and assumptions regarding the average ppm concentrations of 1,4-dioxane under the baseline and the two restriction scenarios. A worst-case assumption was used for the emission estimates with 100% of the surfactant(s) going down the drain.
- The percentage reduction in the emissions of 1,4-dioxane against the baseline was estimated for each of the two restriction scenarios as follows:

$$Emissions\ reduction\ against\ the\ baseline\ (\%) = 1 - (\frac{emissions\ under\ RS}{baseline\ emissions})$$

Qualitative approach

A qualitative thematic approach was adopted to analyse a set of questions included in the survey, covering various economic impacts such as competitiveness, reallocation of operations, among other topics. Thematic analysis entailed systematically identifying and interpreting recurring themes within the responses to discern overarching patterns. Additionally, content analysis was employed to scrutinize this set of questions, involving the systematic categorisation and interpretation of response content to identify recurring topics or ideas. This facilitated an exploration of the prevalence and distribution of specific themes or concepts across responses, illuminating the range and diversity of perspectives within the data. These qualitative methods yielded valuable insights into respondents' perspectives, facilitating a deeper understanding of the anticipated economic and environmental impacts following the introduction of restrictions.

A1.7 COMPARISON OF THE RESTRICTION SCENARIOS

The evidence and conclusions developed through earlier tasks, were brought together to assess how the two restriction scenarios compare with each other and with which type and level of impacts. This will be done using cost-effectiveness analysis and a Multi-Criteria Analysis (MCA) approach, based on Tool #62 of the latest Better Regulation Toolbox and ECHA's guidelines and studies. These are described below.

Cost-effectiveness analysis

Cost-effectiveness analysis has been conducted to provide an evaluation of the restriction scenarios that could be comparable with other policies previously adopted given the lack of evidence that allows for quantitative conclusions. That is, we would be able to compare the cost-effectiveness of the restriction scenarios with that of other policies seeking to reduce emissions of persistent substances.

This analysis focusses on the relationship between the costs incurred and how effectively the two restriction scenarios under consideration might reduce the emissions of 1,4-dioxane. This follows the guidelines outlined by the SEAC, employing a rigorous and established methodology.

The first step involves defining the metrics that will comprise the cost-effectiveness indicators and to develop estimates for comparison with estimations from other policies already adopted. These draw on some type of adjustment or compliance cost estimates, estimates of opportunity costs, and emissions reductions resulting from the restriction scenarios.

As part of the analysis two different definitions of costs and one definition of emissions impacts were considered.

- Compliance or opportunity costs: Adjustment or compliance costs comprise the additional capital and operating expenses incurred by organisations compared to the EU-27 baseline, whereas opportunity costs include these costs as well as all of the production and/or GVA losses against the baseline from the adoption of the restriction scenarios (see also Section 4.1 for more information on costs estimated).
- Reduction in emissions/releases of 1,4-dioxane to the environment: Reductions in emissions/ releases refers to the flow of 1,4-dioxane into the environment without considering any similar environmental dynamics (see Section 4.2 for more information on the reductions of emissions estimated under the two restriction scenarios).

Taking into account these options allows for a comprehensive exploration of how the costs compare with the “effectiveness” of the two restriction scenarios in reducing the emissions of 1,4-dioxane. Two indicators were thus developed:

- Compliance costs per releases avoided
- Opportunity costs per releases avoided

It is our technical opinion that using opportunity costs would be a more appropriate and comprehensive approach to estimating the overall costs associated with achieving some measure of emissions reductions. However, it is also acknowledged that these estimates are even more uncertain than compliance costs. Opportunity costs are significantly larger than compliance costs, and thus employing the later would be a more conservative approach. Further, our understanding is that the approach employed in the past focusses more narrowly on compliance or adjustments costs. Therefore, we used compliance costs estimates for the main cost-effectiveness analysis presented in this Report.

Most of the historical evidence of cost-effectiveness from previous restriction proposals or similar restriction scenarios from ECHA pertains to compliance costs per releases avoided, even though it is acknowledged that it would be more appropriate moving forward to focus on the environmental steady-state stock impacts instead of emissions/releases reductions of the substances of concern. Within this Study, due to the limitations of the data it has not been possible to calculate steady-state stock impacts.

Mathematically, the Net Present Value (NPV) of the compliance costs over the period 2026-2040 were calculated using a real discount rate of 3% in line with the Better Regulation Guidelines. This NPV was annualised for comparison across restriction scenarios. These annualised figures are referred to as an average for shorthand, although they are technically slightly different than averages. Annual average emissions reductions were estimated, across the two metrics. These were not discounted (i.e., discount rate of 0%), which is aligned with approaches employed by ECHA and the principles set out in the Better Regulation Guidelines, valuing emissions reductions equally over time (rather than valuing present emissions reductions more than their future counterparts). Ratios of compliance costs per releases were estimated to produce cost-effectiveness ratios for comparison.

The results are presented in Section 5.1and suggest that the potential costs required to achieve emissions reductions are much higher than those estimated for other similar restriction scenarios seeking to reduce emissions of persistent chemicals.

MCA-based qualitative scoring approach

An overarching qualitative framework was employed to bring together all of the evidence and analysis against each of the two restriction scenarios on a scale of -5/+5, capturing both the estimated magnitude of impact as well as its likely direction when compared to the baseline. The Table below outlines how this scale would be described and presented.

Table _A 6 Scoring and colour coding used to present the assessment conclusions.

Strongly negative	Negative	Weakly negative	No or limited impact	Weakly positive	Positive	Strongly positive	Unclear
-5	-3	-1	0	+1	+3	+5	N/A

The framework facilitates an iterative process that is overseen by the economist lead to ensure that all the evidence is drawn on whilst retaining internal coherence. The following five steps have been taken to assess impacts.

- Step 1: Selected proxy indicators and construct a qualitative and, where possible, quantitative evidence base of the scale of potential impacts identified.
- Step 2: A team of experts from the consultant project team considered and assessed the impacts of policy measures (or options) across each category following some general guidance, accessing the available evidence, and using their expert judgement.
- Step 3: A re-calibration exercise was carried out every time inputs from experts are reviewed by the PM/Lead economist. This ensured that the impact ratings remained internally coherent and are challenged constructively.
- Step 4: An impact aggregation exercise was performed. This exercise was required to aggregate the qualitative rating of impacts across specific categories to the level of broad impacts (economic and environmental) and social costs and benefits. Further aggregation was also done when considering any packaging of restriction scenarios, so that the scale of impacts presented is always from -5/+5.
- Step 5: Validation and quality assurance activities was also taken by a separate team of experts within the team.

In more detail, given the relatively limited quantitative evidence, a number of proxies and approaches were employed to establish qualitative scores and achieve internal coherence (Steps 1-3 above). The following list summarises, at a very high-level, a few references employed in the iterative process to reach a final position on the qualitative ratings for each option and category of impact.

- First, impacts on industrial activity (adjustment) were considered across core restriction scenarios. Evidence collected via the targeted stakeholder survey was essential to establish qualitative scores that were internally coherent (i.e., the relative position of impacts was reasonable across restriction scenarios). The estimated levels of the affected portfolio for the two restriction scenarios were considered as well as the estimates for potential product withdrawal in terms of industry turnover.
- Secondly, these assessments were used as an anchor or benchmark to develop a relative position of impact across the other economic and wider economic categories such as innovation and research, global competitiveness and trade, employment and consumers and households. When impacts were identified on these categories, this was generally judged to be of smaller scale than conduct of business by 3 to 6 points.
- Thirdly, expert judgement was required to establish qualitative scores or ratings for environmental impact categories. These were triangulated with the evidence identified e.g., is there a possibility of significant positive impact on the environment from restricting the use of a particular substance and, if so, what could this look like? The qualitative score was further contrasted with the scale of costs and a judgement was made as to whether a similar scale of benefit could be accrued or not from the adoption of each given restriction scenario.

This qualitative method provides a platform for experts/consultants to triangulate evidence with expert judgement, which is required especially in this context of limited evidence and complex impact pathways. The outputs of this method offer a guide or a best recommendation as to the balance of impacts, costs and benefits given the information, time and resources available, for consideration by the Commission. The conclusions are not irrefutable but present a best view. This is aligned with the principles set out in the Better Regulation Guidelines, including proportionality, and others.

Having iterated and established a rating for each impact category across each restriction scenario, these **scores were aggregated and mapped onto -5/+5 scale** (Step 4 above) at the broad impact level (economic and environmental) and the level of costs and benefits for a higher level and more effective comparison of the restriction scenarios.

- This aggregation and re-calibration can only be effective if the impacts, costs and benefits are on a comparable scale. Therefore, the following steps were undertaken:
- First, the ratings for each of the broad impact categories; the costs (negative ratings); and the benefits (positive ratings) were aggregated.

Following this, a judgment was made to map the highest score in absolute terms “-11” in costs onto the -5/+5 scale as “-5”. This was done to provide as much visibility in the differences of scale of impact across restriction scenarios. However, the mapping could be adjusted without any implications on the conclusions reached as the relative positions of the ratings will remain.

APPENDIX 2 SECTOR DEFINITION

A2.1 OVERVIEW

The collection of data for the manufacturing of surfactants and the downstream user markers has utilised Eurostat datasets which is based on the Structural Business Statistics (SBS)[91] and the Prodcom database[92]. The SBS contains data by industrial sector, following the classification by NACE Rev.2 of economic activities. The Prodcom database provides data on the production of manufactured goods, following a fine classification of products which allows the construction of production values for each of the sectors.

For defining the sectors, NACE sector codes have been defined for the wider sector followed by Prodcom product characterisation which provides a more granular insight into the production value. These classifications have been defined by expert judgement and refined with CESIO.

A2.2 MANUFACTURING SECTOR DEFINITION

The Prodcom product classification used for the manufacturing of surfactants is listed in the Table below.

Table _A 7 Relevant NACE classification and Prodcom classification codes for manufacturing of surfactants

Sector	NACE Sector Codes	Prodcom Product Categories
Manufacturing of surfactants	2014: Manufacture of basic chemicals, fertilisers and nitrogen compounds, plastics and synthetic rubber in primary forms	• 20141120: Saturated acyclic hydrocarbons • 20141190: Unsaturated acyclic hydrocarbons (excluding ethylene, propene, butene, buta-1,3-diene and isoprene) • 20141490: Derivatives of hydrocarbons (excluding those containing only sulpho groups; their salts and ethyl esters, those containing only nitro or only nitroso groups) • 20142100: Industrial fatty alcohols • 20142350: Halogenated, sulphonated, nitrated or nitrosated derivatives of acyclic alcohols • 20142375: Aromatic alcohols and their halogenated, sulphonated, nitrated or nitrosated derivatives • 20145139: Other organo-sulphur compounds • 20146310: Acyclic ethers and their halogenated, sulphonated, nitrated or nitrosated derivatives • 20146325: Aromatic ethers and their halogenated, sulphonated, nitrated or nitrosated derivatives • 20146339: Ether-alcohols and their halogenated, sulphonated, nitrated or nitrosated derivatives (excluding 2,2-Oxydiethanol) • 20146430: Other organic compounds, n.e.c.

A2.3 DOWNSTREAM SECTORS DEFINITION

The Prodcom product classification used for the downstream user sectors is listed in the Table below. These are: Cosmetics and personal care products; Detergents and cleaning products; Paints, Coatings, Adhesives, Elastomers, and Printing Inks; Chemical products for textile and leather; and Agrochemical products and applications.

[91] Eurostat, Structural Business Statistics database. Available from: https://ec.europa.eu/eurostat/web/structural-business-statistics/database
[92] Eurostat, Prodcom database. Available from: https://ec.europa.eu/eurostat/web/prodcom/database

Table _A 8 Relevant downstream sectors by NACE classification and Prodcom classification codes

Sector	NACE Sector Codes	Prodcom Product Categories
Cosmetics and personal care products	2042: Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations	• 20421150: Perfumes • 20421170: Toilet waters • 20421259: Lip make-up preparations • 20421270: Eye make-up preparations • 20421300: Manicure or pedicure preparations • 20421500: Beauty, make-up and skin care preparations including suntan (excluding medicaments, lip and eye make-up, manicure and pedicure preparations, powders for cosmetic use and talcum powder) • 20421630: Shampoos • 20421650: Preparations for permanent waxing or straightening of hair • 20421670: Hair lacquers • 20421700: Hair preparations (excluding shampoos, permanent waving and hair straightening preparations, lacquers) • 20421850: Dentifrices (including toothpaste, denture cleaners) • 20421890: Preparations for oral or dental hygiene (including denture fixative pastes; powders and tablets, mouth washes and oral perfumes, dental floss) (excluding dentifrices) • 20421915: Soap and organic surface-active products in bars, etc., for toilet use • 20421930: Organic surface-active products and preparations for washing the skin; whether or not containing soap, p.r.s. • 20421945: Pre-shave, shaving and after-shave preparations (excluding shaving soap in blocks) • 20421960: Personal deodorants and anti-perspirants • 20421975: Perfumed bath salts and other bath preparations • 20421990: Other personal preparations (perfumeries, toilet, depilatories...)

Sector	NACE Sector Codes	Prodcom Product Categories
Detergents and cleaning products	2041: Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations	• 20412020: Anionic organic surface-active agents (excluding soap) • 20412030: Cationic organic surface-active agents (excluding soap) • 20412050: Non-ionic organic surface-active agents (excluding soap) • 20412090: Organic surface-active agents (excluding soap, anionic, cationic, non-ionic) • 20413120: Soap and organic surface-active products in bars, etc., n.e.c. • 20413150: Soap in the form of flakes, wafers, granules or powders • 20413180: Soap in forms excluding bars, cakes or moulded shapes, paper, wadding, felt and non-wovens impregnated or coated with soap/detergent, flakes, granules or powders • 20413240: Surface-active preparations, whether or not containing soap, p.r.s. (excluding those for use as soap) • 20413250: Washing preparations and cleaning preparations, with or without soap, p.r.s. including auxiliary washing preparations excluding those for use as soap, surface-active preparations • 20413260: Surface-active preparations, whether or not containing soap, n.p.r.s. (excluding those for use as soap) • 20413270: Washing preparations and cleaning preparations, with or without soap, n.p.r.s. including auxiliary washing preparations excluding those for use as soap, surface-active preparations • 20414100: Preparations for perfuming or deodorising rooms • 20414270: Artificial and prepared waxes of polyethylene glycol • 20414280: Artificial and prepared waxes (including sealing waxes) (excluding of polyethylene glycol) • 20414350: Polishes, creams and similar preparations, for the maintenance of wooden furniture, floors or other woodwork (excluding artificial and prepared waxes) • 20414370: Polishes and similar preparations, for coachwork (excluding artificial and prepared waxes, metal polishes) • 20414383: Metal polishes • 20414389: Other polishes, creams and similar preparations, n.e.c. • 20414400: Scouring pastes and powders and other scouring preparations
Paints, Coatings, Adhesives, Elastomers, and Printing Inks	2017: Manufacture of basic chemicals, fertilisers and nitrogen compounds, plastics and synthetic rubber in primary forms	• 20171050: Synthetic latex rubber • 20171090: Synthetic rubber (excluding latex)

Sector	NACE Sector Codes	Prodcom Product Categories
	2030: Manufacture of paints, varnishes and similar coatings, printing ink and mastics	• 20301150: Paints and varnishes, based on acrylic or vinyl polymers dispersed or dissolved in an aqueous medium (including enamels and lacquers) • 20301170: Other paints, varnishes dispersed or dissolved in an aqueous medium • 20301225: Paints and varnishes, based on polyesters dispersed/dissolved in a non-aqueous medium, weight of the solvent > 50 % of the weight of the solution including enamels and lacquers • 20301229: Paints and varnishes, based on polyesters dispersed/dissolved in a non-aqueous medium including enamels and lacquers excluding weight of the solvent > 50 % of the weight of the solution • 20301230: Paints and varnishes, based on acrylic or vinyl polymers dispersed/dissolved in non-aqueous medium, weight of the solvent > 50 % of the solution weight including enamels and lacquers • 20301250: Other paints and varnishes based on acrylic or vinyl polymers • 20301270: Paints and varnishes: solutions n.e.c. • 20302213: Oil paints and varnishes (including enamels and lacquers) • 20302215: Prepared water pigments for finishing leather; paints and varnishes (including enamels, lacquers and distempers) (excluding of oil) • 20302220: Prepared driers • 20302240: Pigments, including metallic powders and flakes, dispersed in non-aqueous media, in liquid or paste form, of a kind used in the manufacture of paints; colorants and other colouring matter, n.e.c. put up for retail sale • 20302255: Painters' fillings • 20302260: Non-refractory surfacing preparations for façades, indoor walls, floors, ceilings or the like • 20302273: Organic composite solvents and thinners used in conjunction with coatings and inks; based on butyl acetate • 20302279: Organic composite solvents and thinners used in conjunction with coatings and inks (excluding those based on butyl acetate) • 20302350: Artists', students', or signboard painters' colours, amusement colours and modifying tints in sets of tablets, tubes, jars, bottles or pans • 20302370: Artists', students' or signboard painters' colours, amusement colours and modifying tints in tablets, tubes, jars, bottles or pans (excluding in sets) • 20302450: Black printing inks • 20302470: Printing inks (excluding black)
	2052: Manufacture of other chemical products	• 20521060: Glues based on starches, dextrins or other modified starches • 20521080: Prepared glues and other prepared adhesives, n.e.c.

Sector	NACE Sector Codes	Prodcom Product Categories
Chemical products for the textiles and leather sector	2012: Manufacture of basic chemicals, fertilisers and nitrogen compounds, plastics and synthetic rubber in primary forms	• 20121990: Other inorganic bases; other metal oxides, hydroxides and peroxides, n.e.c. • 2012210: Disperse dyes and preparations based thereon • 20122120: Acid and mordant dyes and preparations based thereon • 20122130: Basic dyes and preparations based thereon • 20122140: Direct dyes and preparations based thereon • 20122150: Other synthetic organic colouring matters • 20122160: Synthetic organic products used as fluorescent brightening agents • 20122250: Tanning extracts of vegetable origin; tannins and their salts, ethers, esters and other derivatives • 20122330: Synthetic organic tanning substances • 20122350: Inorganic tanning substances; tanning preparations; enzymatic preparations for pre-tanning • 20122415: Pigments and preparations based on titanium dioxide containing >= 80 % by weight of titanium dioxide • 20122419: Pigments and preparations based on titanium dioxide (excluding those containing >= 80 % by weight of titanium dioxide) • 20122450: Other colouring matter; pigments and preparations based on inorganic or mineral colouring matter; inorganic products of a kind used as luminophores
	2059: Manufacture of other chemical products	• 20595570: Finishing agents, etc, used in the textile industry (excluding with amylaceous basis) • 20595590: Finishing agents, dye carriers and other preparations, n.e.c.

Agrochemical products and applications	2020: Manufacture of pesticides and other agrochemical products	• 20201130: Insecticides based on chlorinated hydrocarbons, put up in forms or packings for retail sale or as preparations or articles (excluding hazardous pesticides) • 20201140: Insecticides based on carbamates, put up in forms or packings for retail sale or as preparations or articles (excluding hazardous pesticides) • 20201150: Insecticides based on organophosphorus products, put up in forms or packings for retail sale or as preparations or articles (excluding hazardous pesticides) • 20201160: Insecticides based on pyrethroids, put up in forms or packings for retail sale or as preparations or articles (excluding hazardous pesticides) • 20201190: Other insecticides (excluding hazardous pesticides) • 20201220: Herbicides based on phenoxy-phytohormone products, put up in forms or packings for retail sale or as preparations or articles (excluding hazardous pesticides) • 20201230: Herbicides based on triazines, put up in forms or packings for retail sale or as preparations or articles (excluding hazardous pesticides) • 20201240: Herbicides based on amides, put up in forms or packings for retail sale or as preparations or articles (excluding hazardous pesticides) • 20201250: Herbicides based on carbamates, put up in forms or packings for retail sale or as preparations or articles (excluding hazardous pesticides) • 20201260: Herbicides based on dinitroanilines derivatives, put up in forms or packings for retail sale or as preparations or articles (excluding hazardous pesticides) • 20201270: Herbicides based on urea; uracil and sulphonylurea, put up in forms or packings for retail sale or as preparations or articles (excluding hazardous pesticides) • 20201290: Herbicides p.r.s. or as preparations/articles excluding based on phenoxy-phytohormones, triazines, amides, carbamates, dinitroanaline derivatives, urea, uracil, sulphonylurea (excluding hazardous pesticides) • 20201350: Anti-sprouting products put up in forms or packings for retail sale or as preparations or articles • 20201370: Plant-growth regulators put up in forms or packings for retail sale or as preparations or articles • 20201430: Disinfectants based on quaternary ammonium salts put up in forms or packings for retail sale or as preparations or articles (excluding hazardous pesticides) • 20201450: Disinfectants based on halogenated compounds put up in forms or packings for retail sale or as preparations (excluding hazardous pesticides) • 20201490: Disinfectants put up in forms or packings for retail sale or as preparations or articles (excluding those based on quaternary ammonium salts, those based on halogenated compounds and those being hazardous pesticides) • 20201515: Inorganic fungicides, bactericides and seed treatments, put up in forms or packings for retail sale or as preparations or articles (excluding hazardous pesticides) • 20201530: Fungicides, bactericides and seed treatments based on dithiocarbamates, put up in forms or packings for retail sale or as preparations or articles (excluding hazardous pesticides) • 20201545: Fungicides, bactericides and seed treatments based on benzimidazoles, put up in forms or packings for retail sale or as preparations or articles (excluding hazardous pesticides)

- 20201560: Fungicides, bactericides and seed treatment based on triazoles or diazoles, put up in forms or packings for retail sale or as preparations or articles (excluding hazardous pesticides)
- 20201575: Fungicides, bactericides and seed treatments based on diazines or morpholines, put up in forms or packings for retail sale or as preparations or articles (excluding hazardous pesticides)
- 20201590: Other fungicides, bactericides and seeds treatments (ex: Captan,...) (excluding hazardous pesticides)
- 20201600: Goods of heading 3808 containing one or more of the following substances: aldrin (ISO); binapacryl (ISO); camphechlor (ISO) (toxaphene); captafol (ISO); chlordane (ISO); chlordimeform (ISO); chlorobenzilate (ISO); DDT (ISO) (clofenotane (INN), 1,1,1-trichloro-2,2-bis(p-chlorophenyl) ethane); dieldrin (ISO, INN); 4,6-dinitro-o-cresol (DNOC (ISO)) or its salts; dinoseb (ISO), its salts or its esters; ethylene dibromide (ISO) (1,2-dibromoethane); ethylene dichloride (ISO) (1,2-dichloroethane); fluoroacetamide (ISO); heptachlor (ISO); hexachlorobenzene (ISO); 1,2,3,4,5,6 -hexachlorocyclohexane (HCH (ISO)), including lindane (ISO, INN); mercury compounds; methamidophos (ISO); monocrotophos (ISO); oxirane (ethylene oxide); parathion (ISO); parathion-methyl (ISO) (methyl-parathion); pentachlorophenol (ISO), its salts or its esters; phosphamidon (ISO); 2,4,5-T (ISO) (2,4,5-trichlorophenoxyacetic acid), its salts or its esters; tributyltin compounds. Also dustable powder formulations containing a mixture of benomyl (ISO), carbofuran (ISO) and thiram (ISO).
- 20201980: Rodenticides and other plant protection products put up for retail sale or as preparations or articles (excluding insecticides, fungicides, herbicides, disinfectants and hazardous pesticides)
- 20201591: Other fungicides, bactericides and seeds treatments (ex: Captan,...) (excluding hazardous pesticides, carbofuran (ISO) and trichlorfon (ISO))
- 20201610: Goods of heading 3808 containing one or more of the following substances: Aldrin (ISO); binapacryl (ISO); camphechlor (ISO) (toxaphene); captafol (ISO); chlordane (ISO); chlordimeform (ISO); chlorobenzilate (ISO); DDT (ISO) (clofenotane (INN), 1,1,1-trichloro-2,2-bis(p- chlorophenyl) ethane); dieldrin (ISO, INN); 4,6-dinitro-o- cresol (DNOC (ISO)) or its salts; dinoseb (ISO), its salts or its esters; ethylene dibromide (ISO) (1,2-dibromoethane); ethylene dichloride (ISO) (1,2-dichloroethane); fluoroacetamide (ISO); heptachlor (ISO); hexachlorobenzene (ISO); 1,2,3,4,5,6 -hexachlorocyclohexane (HCH (ISO)), including lindane (ISO, INN); mercury compounds; methamidophos (ISO); monocrotophos (ISO); oxirane (ethylene oxide); parathion (ISO); parathion-methyl (ISO) (methyl-parathion); pentachlorophenol (ISO), its salts or its esters; phosphamidon (ISO); 2,4,5-T (ISO) (2,4,5-trichlorophenoxyacetic acid), its salts or its esters; tributyltin compounds. Also dustable powder formulations containing a mixture of benomyl (ISO), carbofuran (ISO), trichlorfon (ISO) and thiram (ISO)
- 20201930: Goods of heading 3808 containing one or more of the following substances: aldrin (ISO); binapacryl (ISO); camphechlor (ISO) (toxaphene); captafol (ISO); chlordane (ISO); chlordimeform (ISO); chlorobenzilate (ISO); DDT (ISO) (clofenotane (INN), 1,1,1-trichloro-2,2-bis(p-chlorophenyl) ethane); dieldrin (ISO, INN); 4,6-dinitro-o-cresol (DNOC (ISO)) or its salts; dinoseb (ISO), its salts or its esters; ethylene dibromide (ISO) (1,2-dibromoethane); ethylene dichloride (ISO) (1,2-dichloroethane); fluoroacetamide (ISO); heptachlor (ISO); hexachlorobenzene (ISO); 1,2,3,4,5,6 -hexachlorocyclohexane (HCH (ISO)), including lindane (ISO, INN); mercury compounds; methamidophos (ISO); monocrotophos (ISO); oxirane (ethylene oxide); parathion (ISO); parathion-methyl (ISO) (methyl-parathion); pentachlorophenol (ISO), its salts or its

Sector	NACE Sector Codes	Prodcom Product Categories
		esters; phosphamidon (ISO); 2,4,5-T (ISO) (2,4,5-trichlorophenoxyacetic acid), its salts or its esters; tributyltin compounds. Also dustable powder formulations containing a mixture of benomyl (ISO), carbofuran (ISO) and thiram (ISO)

APPENDIX 3 SURFACTANT DESCRIPTION AND 1,4-DIOXANE FORMATION

A3.1 OVERVIEW

This Appendix provides complimentary technical information on the following aspects:

- Definition of surfactants
- Uses of surfactants
- Formation of 1,4-dioxane during the manufacture of EO-based surfactants

Please note that, as discussed in the 1,4-Dioxane RMOA[93] and other literature investigated as part of this study, surfactants are only one source or example of 1,4-dioxane formation.

A3.2 DEFINITION OF SURFACTANTS

There is currently no definition for surfactants or surfactant products in REACH. Surfactants have been defined by CESIO as "*any surface-active organic substance or mixture which consists of one or more hydrophilic groups and one or more hydrophobic groups and one or more hydrophobic groups of such a nature and size that is capable of fulfilling both of the following criteria:*[94]

- *Forms a clear micellar solution or a translucent microemulsion or stable emission without the separation of insoluble matter when mixed with water at a concentration of 0.5 wt.% and left to stand for one hour at 20 °C;*
- *Reduces the surface tension of water to <45 mN/m at a concentration of 0.5 wt.% at 20 °C.*"

A3.3 USES OF SURFACTANTS

Surfactants are surface active agents which consist of a hydrophobic (water-insoluble) 'tail' group and a hydrophilic (water-soluble) 'head' group. Surfactants reduce the surface tension of water and also have an affinity for oils and dirt. From this molecular structure, surfactants are used for foaming, cleaning and emulsifying properties[95]. Due to these properties, surfactants are formulated in a number of products as cleaning and/or emulsifying properties which include in shampoos, body washes, skin creams, sunscreen and paints amongst others[96].

There are a number of different chemical types of surfactants including anionic surfactants, non-ionic surfactants, amphoteric surfactants and cationic substances[97]. Ethylene oxide is used in the manufacture of EO-based surfactants, and this reacts to form ethylene glycol in surfactants. The ethoxylate group in surfactants derived from ethylene oxide can be either the sole hydrophilic head group in the ethoxylate surfactant or form part of the hydrophilic head group in the ethoxylate surfactant[98].

A3.4 FORMATION OF 1,4-DIOXANE

1,4-dioxane is formed as a by-product during the manufacture of EO-surfactants and the subsequent further deviation of EO-surfactants (where relevant). In this section, the mechanisms of the formation of 1,4-dioxane are described.

General mechanism of 1,4-dioxane formation during ethoxylation

The general mechanism of 1,4-dioxane formation from EO-surfactants during the ethoxylation process is illustrated in the following figure.

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93 BAuA (2020). Risk Management Option Analysis Conclusion Document 1,4-dioxane. Available from: https://echa.europa.eu/documents/10162/010b37a1-9d0d-a69e-a703-df8626102fae

94 CESIO (2023). Call for evidence on a possible restriction of 1,4-dioxane containing surfactants. Response to BAuA. Dated 17 July 2023.

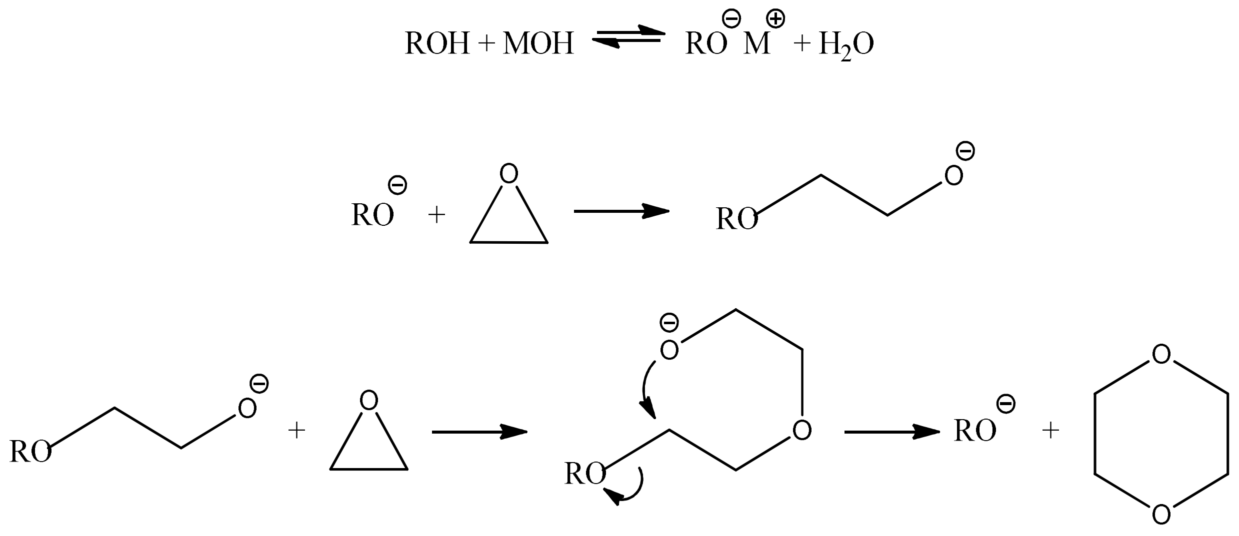
95 CESIO (2024). What are surfactants? Available at: https://www.cesio.eu/index.php/about-surfactants

96 CESIO (2024). Applications. Available at: https://www.cesio.eu/index.php/applications

97 Sakamoto K et al (ed) (2017). Cosmetic Science and Technology. Elsevier Inc.

98 Survey respondent

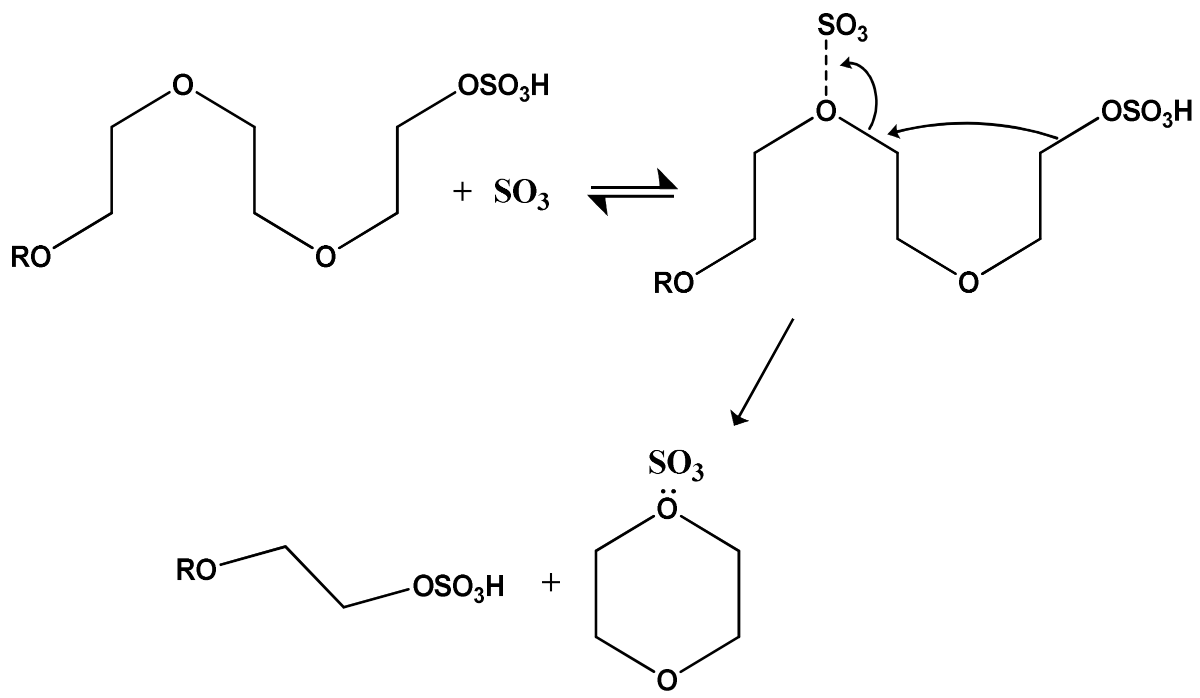
Figure A 1 Mechanism of 1,4-dioxane formation[99]



1,4-dioxane formation during the sulfation process of alcohol ethoxylates

The mechanism of 1,4-dioxane formation during the sulfation process of alcohol ethoxylation is illustrated in the following figure.

Figure A 2 Mechanism of 1,4-dioxane formation during the sulfation process of alcohol ethoxylates[99]



[99] Survey respondent

Routes for the formation of 1,4-dioxane during the manufacture of ethoxylate surfactants

In the manufacture of specific ethoxylate surfactants, there are known or potential formation routes to the formation of 1,4-dioxane. These include for the following surfactants[100]:

- 1,4-dioxane is formed during the manufacture of alcohol ethoxylates from ethylene oxide and one of the following substances fatty alcohol/alkyl phenol/castor oil/sorbitan ester/tristyryl phenol.
- 1,4-dioxane is formed during the manufacture of fatty acid methyl ester ethoxylate from fatty acid methyl ester and ethylene oxide in the presence of a catalyst.
- 1,4-dioxane is formed during the sulfation of fatty alcohol ethoxylates to produce sodium alkyl ether sulfates. This is in addition to the 1,4-dioxane formed during the manufacture of the fatty alcohol ethoxylate which is illustrated in the previous figure.
- 1,4-dioxane is formed during the phosphorylation of alcohol ethoxylates to produce alcohol ethoxylation phosphate ester. This is in addition to the 1,4-dioxane formed during the manufacture of the fatty alcohol ethoxylate which is illustrated in the previous figure.
- In the manufacture of alkyl ester carboxylate, 1,4-dioxane could be formed during the carboxymethylation of alcohol ethoxylation to produce the alkyl ether carboxylate.

[100] Survey respondent

APPENDIX 4 AFFECTED PORTFOLIO

The surfactants currently on the EU-27 market, as identified through literature research and stakeholder consultation, have been listed in the Table below. This table includes the average estimated 1,4-dioxane level in each of the affected surfactants and the restriction scenario/s which may impact their use.

Table _A 9 The surfactants impacted by the restriction scenarios and their respective key sectors of use.

Primary Grouping	Most frequently reported use sector	Other sectors of use	Most frequent estimation of concentration	Relevant restriction scenarios
Anionics				
Alkyl ether sulfates	Cosmetics and personal care	Detergents and cleaning products; Paints, coatings, adhesives, elastomers, and printing inks	>10 ppm	RS1 and RS2
Alkyl ether carboxylates	Detergents and cleaning products	Lubricants, metal working, oilfield/mining	Between 1 ppm and 10 ppm	RS1
Alkyl ether phosphates	Agrochemical applications	Paints, coatings, adhesives, elastomers, and printing inks, metal working	>10 ppm	RS1 and RS2
Sulphosuccinates - Alkyl ether carboxylates and derivatives	Cosmetics and personal care	-	Between 1 ppm and 10 ppm	RS1
Other anionics	Cosmetics and personal care	Other (DU)	<1 ppm	Not impacted
Non-ionics				
Fatty alcohol ethoxylates	Detergents and cleaning products	Chemical products for textile and leather	Between 1 ppm and 10 ppm	RS1
a. Natural	Detergents and cleaning products	-	Between 1 ppm and 10 ppm	RS1
b. Synthetic	Detergents and cleaning products	-	Between 1 ppm and 10 ppm	RS1
Fatty acid ethoxylates	Textiles and leather	Detergents and cleaning products	>10 ppm	RS1 and RS2
Fatty acid esters, ethoxylated - Alkyl ether carboxylates and derivatives	Cosmetics and personal care	Chemical products for textile and leather	>10 ppm	RS1 and RS2
Fatty amine ethoxylates	Detergents and cleaning products	Chemical products for textile and leather	>10 ppm	RS1
Alkyl mixed alkoxylates	Detergents and cleaning products	Chemical products for textile and leather	Between 1 ppm and 10 ppm	RS1
EO/PO copolymers	Cosmetics and personal care	Detergents and cleaning products	Between 1 ppm and 10 ppm	RS1
Other ethoxylates	Cosmetics and personal care	-	Between 1 ppm and 10 ppm	RS1

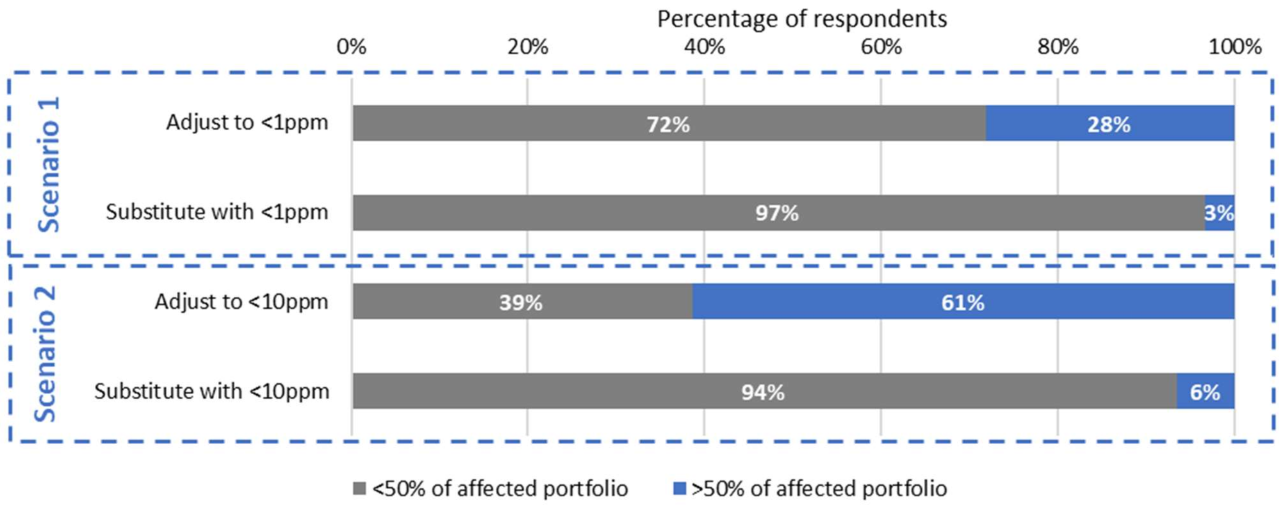
APPENDIX 5 EVIDENCE REVIEW OF ALTERNATIVES

The use of surfactants containing 1,4-dioxane across multiple applications will be impacted by the restriction scenarios. In the following section the expected response from industry, both manufacturers, importers and downstream users will be considered.

Under the two restriction scenarios **manufacturers and/or importers** of surfactants will have to decide whether to stop producing surfactants which contain relevant levels of 1,4-dioxane (1 ppm or more or 10 ppm or more) and either use alternatives and/or 1.4-dioxane removal technologies to adjust and lower the concentrations. Additionally, there are alternative methods of production which result in lower concentrations of 1,4-dioxane in the final formulation however, these are not considered here as, from research and stakeholder feedback, these methods would require large process changes and adaptation of manufacturing facilities which would be avoided unless necessary.

Manufacturers (and/or importers) of surfactants which contain 1,4-dioxane were asked to consider the extent to which they might adjust, produce and/or import alternative surfactants to accommodate a REACH restriction of surfactant products with active matter containing 1,4-dioxane over the next 15 years. The Figure below shows the proportion of survey respondents[101] that may adjust or substitute less or more than 50% of their affected portfolio under each scenario.

Figure A 3 The proportion of surfactant manufacturers and importers which would adjust the concentration of 1,4-dioxane to the required level or use a substitution.



The Figure presents that, under restriction scenario 1, 72% of relevant survey respondents would adjust less than 50% of their affected portfolio. Whereas under restriction scenario 2 only 39% of respondents would adjust less than 50% of their affected portfolio and the majority would adjust more than 50% of their affected portfolio. This means that companies are more likely to adjust a higher proportion of the surfactants they currently manufacture, through methods such as stripping, under restriction scenario 2.

The vast majority of respondents (94-97%) also stated that they would substitute or find complete alternatives for less than 50% of their affected portfolios, highlighting that adjustment through stripping appears to be more likely and/or preferred response especially under restriction scenario 2.

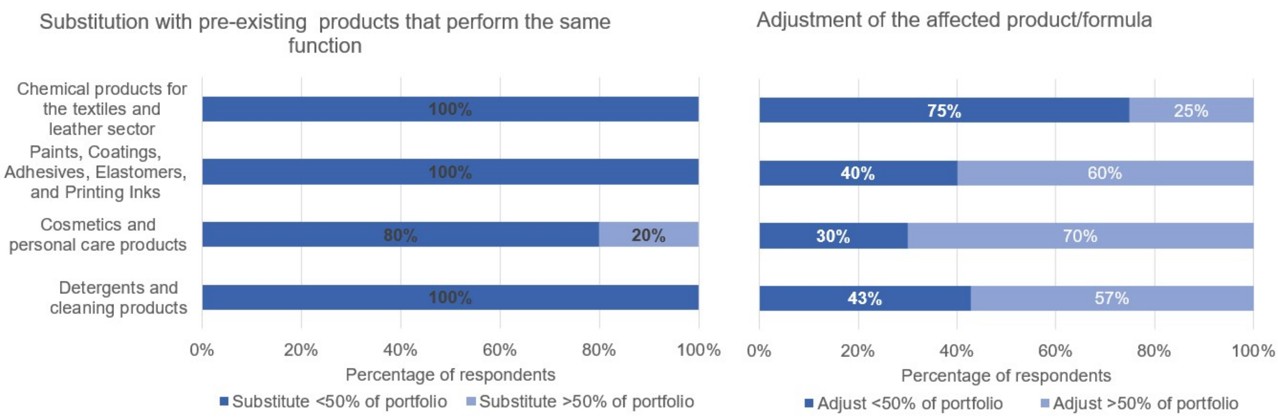
Products that would be potentially affected under each restriction scenario, which cannot be adjusted or substituted, would be withdrawn and their production in (and/or import into) the EU would cease. Estimates of potential market losses can be found in Section 4.1.1 of this report.

Downstream users of surfactants could also choose to adjust their products to reduce the presence of 1,4-dioxane (or surfactants with 1,4-dioxane content), substitute the surfactants that they currently use with alternatives containing lower 1,4-dioxane content (below the 1 ppm or 10ppm thresholds), and/or substitute their products with 1,4-dioxane free alternatives already available or ready to be commercialised.

[101] For information on the survey sample size, please refer to Sections 4.1.1 and Appendix 6.

We issued an online survey to downstream user companies and asked participants to indicate the proportion of their portfolio they would be able to adjust and how. The Figure below summarises some of the findings.

Figure A 4 The proportion of respondents across each downstream user sector that suggested <50% or >50% of their affected portfolio could be adjusted or substituted under either scenario.



Under either restriction scenario, downstream user survey participants reported estimates of the proportion of their product portfolio containing surfactants with 1,4-dioxane content above 1 ppm that they would adjust or substitute. Survey respondents reported that substitution is less likely than making product adjustments to comply with the restriction scenarios: the majority of respondents reported they could substitute less than 50% of their potentially affected product portfolio, whereas the majority of respondents across the 'detergents and cleaning products', 'cosmetics and personal care products' and 'paints, coatings, adhesives, elastomers and printing inks' sectors indicated they would be able to adjust more than 50% of their potentially affected product portfolio. Respondents from the 'chemical products for the textiles and leather' sector were the exception, indicating that less than 50% of their affected portfolio could be adjusted.

The following subsections provide an overview of **alternative surfactants or substances** and **the stripping processes** that were identified as potential viable options for businesses to adapt under the restriction scenarios.

Alternative Substances

Respondents were asked to specify alternatives to ethoxylated surfactants that they have considered or will consider bringing to the market in response to the REACH restriction scenarios. Additionally, literature sources such as the US EPA document on nonylphenol ethoxylate alternatives and ChemSec's Marketplace platform have been reviewed and alternatives extracted[102,103]. These sources have been collated and refined to produce the long list of alternatives as shown in the Table below. The highlighted substances are alternatives that have been suggested by multiple respondents and/or across multiple sources.

Table _A 10 Longlist of suggested alternatives for 1,4-dioxance containing substances.

Substance name	CAS number	Replacing	REACH registered tonnes per annum	Sectors
Sodium lauroyl isethionate	7381-01-3	-	≥ 1 000 to < 10 000	Cosmetics and personal care
D-Glucopyranose, oligomeric, C10-16 (even numbered) alkyl glycosides	110615-47-9	Alcohol ether sulphate	10 000 to < 100 000	Cosmetics and personal care, detergents and cleaning products.

[102] ChemSec, n/a, Marketplace. Available from: Safer Alternatives | ChemSec Marketplace Accessed May 2024.

[103] US EPA (2021). DfE Alternatives Assessment for Nonylphenol Ethoxylates. Available from: DfE Alternatives Assessment for Nonylphenol Ethoxylates - May 2012 (epa.gov)

Substance name	CAS number	Replacing	REACH registered tonnes per annum	Sectors
Alcohol sulphate	1231880-35-5	Alkyl ether sulphate	n/a	Detergents and cleaning products
D-Glucitol, 1-deoxy-1-(methylamino)-N-C8-C10 acryl. derivs.	1591782-62-5	-	n/a	Cosmetics and personal care, detergents and cleaning products, agrochemical application.
D-Glucitol, 1-deoxy-1-(methylamino)-, N-(C16-C18 and C18-unstad. acyl) derivs.	1591782-99-8	-	n/a	Cosmetics and personal care, detergents and cleaning products.
D-Glucitol, 1-deoxy-1-(methylamino)-N-coco acyl derivates	1591783-13-9	-	n/a	Cosmetics and personal care, detergents and cleaning products
Glycolipids	2102535-74-8	Sodium laureth sulphate	n/a	Cosmetics and personal care
Fatty acids, C12-C14 (even numbered), α-sulfo, disodium salts	2215087-54-8	Alcohol ethersulphate	100-1000 t/a	Cosmetics and personal care, detergents and cleaning products.
Amines, C12-14 (even numbered) - alkyldimethyl,N-oxides	308062-28-4	-	≥ 10 000 to < 100 000	Detergents and cleaning products
Sodium lauryl methyl taurate	4337-75-1	Sodium Lauryl Ether Sulphates	100-1000 t/a	Cosmetics and personal care
Rhamnolipids, Sugar derivs	4348-76-9	-	0-10 t/a	Cosmetics and personal care, detergents and cleaning products.
Sodium cocoyl isthionate	61789-32-0	-	1000-10000 t/a	Cosmetics and personal care
Cocoamidopropyl Betaine	61789-40-0	-	≥ 10 to < 100	Cosmetics and personal care, detergents and cleaning products.
Sodium N-coconut acid-N-methyl-taurate	61791-42-2	-	1000-10000 t/a	Cosmetics and personal care
2-Ethyl hexanol EoPo copolymer (9 EO)	64366-70-7	-	n/a	Paints and coatings, agrochemical application, chemical products for textile and

Substance name	CAS number	Replacing	REACH registered tonnes per annum	Sectors
				leather, detergents and cleaning products.
Fatty acids, coco, esters with cottonseed-oil fatty acids, polyglycerol and soya fatty acids	67784-82-1	-	n/a	Cosmetics and personal care
Ammonium lauryl sulphate	68081-96-9	-	n/a	Cosmetics and personal care
C12-15 Alcohols, ethoxylated (9EO)	68131-39-5	-	≥ 100 to < 1 000	Cosmetics and personal care, Detergents and cleaning. products, chemical products for textile and leather.
Benzenesulfonic acid, C10-13-alkyl derivs., sodium salts	68411-30-3	Sodium laureth sulphate	≥ 100 000 to < 1 000 000	Detergents and cleaning products
Sodium C14-16 Olefin Sulfonate	68439-57-6	Sodium lauryl ether sulphates	≥ 10 000 to < 100 000	Cosmetics and personal care, detergents and cleaning products.
D-Glucopyranose, oligomeric, decyl octyl glycosides	68515-73-1	-	≥ 10 000 to < 100 000	Detergents and cleaning products, agrochemical application and chemical products for textile and leather.
Sodium Coco Sulfate	68955-19-1	-	≥ 10 000 to < 100 000	Cosmetics and personal care
Linear Alkyl Benzene Sulphonic Acid	85536-14-7	-	≥ 100 000 to < 1 000 000	Detergents and cleaning products
Sodium dodecylpoly(oxyethylene) sulfate	9004-82-4	Alkyl ethersulphate	n/a	Cosmetics and personal care, detergents and cleaning products.
Sulphuric acid, mono-C12-14-alkyl ester, sodium salts	85586-07-8	Alkyl ethersulphate	≥ 10 000 to < 100 000	Cosmetics and personal care, detergents and cleaning products.
Sodium lauroyl methyl isethionate	928663-45-0	-	n/a	Cosmetics and personal care

The performance of each alternative within each sector (such as personal care) and role (such as emulsifying agent) has not been researched here due to the multitude of possibilities. It is expected that the suggested alternatives will be viable alternatives for specific roles in certain sectors and therefore a more tailored approach will be needed to replace ethoxylate surfactants which are broadly used across many sectors and roles. However, there was doubt from respondents regarding if these alternatives would be able to offer the same performance as the current surfactants in use, and on their availability on the EU-27 market. Based on existing supply of these alternatives in the EU-27, as estimated using REACH registration data, the selection of available alternatives is further limited. For high volume applications multiple alternatives maybe needed and large increases in production or import volumes in the EU-27 would be required.

The longlist of alternatives includes all alternatives with under 10 ppm, under 1 ppm and no 1,4-dioxane content. Of the alternatives listed in the Table above not all will comply with the requirements under restriction scenario 1 (limit of 1 ppm) as some may include higher concentrations. Some respondents commented that under restriction scenario 1 specific EO-based surfactants such as fatty acid, fatty amine, and other ethoxylates will be difficult to substitute, therefore, stripping of the 1,4-dioxane content is the preferable response this is aligned with the industry response displayed in Figure A 1 above.

<u>Technologies to reduce and remove 1,4-dioxane from surfactants</u>

As noted above, under RS1 and RS2 a potential response from businesses could be to reduce the levels of 1,4-dioxane in surfactants during manufacturing. Following this, the wastewater containing the stripped 1,4-dioxane would need to be treated to keep the current level of 1,4-dioxane emissions, or even lower them – the preliminary draft entry text is requiring wastewater to be “free of” 1,4-dioxane This is further discussed in section 4.2.3 of the SEA.

Within the survey, respondents were asked to specify what removal technologies are available to reduce the presence of 1,4-dioxane as an impurity in their surfactant products under the two scenarios. Additionally, literature sources such as the scientific literature and documentation from the manufacturers of the removal technologies were also reviewed.

For reducing the levels of 1,4-dioxane during manufacturing, the stripping of 1,4-dioxane (i.e. vacuum steam stripping) can be performed and is the preferred approach from respondents in response to both restriction scenarios. Some respondents are also performing this process. This technology is commercially available (with a current Technology Readiness Level (TRL) of 9[104,105]. This stripping process involves the use of a vacuum to remove volatile components such as 1,4-dioxane from a detergent slurry under controlled conditions of temperature and pressure. An example of this application is the Ballestra Vacuum Neutralization Technology, in which a dioxane content of below 10 ppm could be achieved[106]. Levels of 1-5 ppm 1,4-dioxane have been reported as achieved using this stripping processes for ethoxylated fatty acid sulphates[107]. As a consequence of this process, wastewater containing 1,4-dioxane is generated and will need to be treated to keep the current level of 1,4-dioxane emissions, or even lower them – the preliminary draft entry text is requiring wastewater to be “free of” 1,4-dioxane.

A selection of currently available technologies suggested by respondents and from the literature are described in the following table along with their respective Technological Readiness Levels (TRLs)[108] for the two restriction scenarios are described in the following table. A limit of 5 ppm of dioxane is generally seen as possible by respondents, for example by using techniques such as AOP or incineration.

However, for the technologies presented to reduce 1,4-dioxane concentrations many are expected to be energy intensive. This is considered in more detail in Section 4.2.4.

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[104] Commission Decision C(2014) 4995. Horizon 2020 – Technology readiness levels (TRLs). Available at: https://ec.europa.eu/research/participants/data/ref/h2020/wp/2014_2015/annexes/h2020-wp1415-annex-g-trl_en.pdf

[105] TRLs refer to the maturity of technologies with the following levels: TRL 1- basic principles observed, TRL 2- technology concept formulated, TRL 3- experimental proof of concept, TRL 4- technology validated in lab, TRL 5- technology validated in relevant environment, TRL 6- technology demonstrated in relevant environment, TRL 7- system prototype demonstration in operational environment, TRL 8- actual system proven in operational environment, TRL 9- Actual system proven through successful mission operation.

[106] Ballestra (2024). Neuralisation and Dioxane Removal. Available at: https://www.ballestra.com/detergents-surfactants/surfactants/neutralization-and-dioxane-removal

[107] Hayes D.G. et al (2022). Precise measurement of 1,4-dioxane concentration in cleaning products: A review of the current state-of-the-art. J Surfact Deterg., 25, 729-741. Available from: https://aocs.onlinelibrary.wiley.com/doi/pdf/10.1002/jsde.12633

[108] Commission Decision C(2014) 4995. Horizon 2020 – Technology readiness levels (TRLs). Available at: https://ec.europa.eu/research/participants/data/ref/h2020/wp/2014_2015/annexes/h2020-wp1415-annex-g-trl_en.pdf

Table _A 11 Removal technologies

Technology	Technological Readiness Level (TRL)[109]	Technology Description
Adsorption	TRL 4-6	Activated carbon have a large surface area with small, low-volumes pores enabling adsorption or chemical reactions. Activated carbon filters utilise adsorption to purify solutions of organic molecules and chemicals[110].
Advanced oxidation (including the use of Fenton's reagent)	TRL 9	Advanced oxidation breaks down organic materials (such as 1,4-dioxane) in water and wastewater by oxidation through reactions of hydroxyl radicals in chemical treatment procedures[111]. Advanced oxidation can also include the use of Fenton's reagent (solution of hydrogen peroxide and an iron catalyst). In one reported study, a reduction of 1,4-dioxane from ~300 ppm to 5 ppm of 1,4-dioxane has been reported[112].
Incineration	TRL 9	This involves the incineration of wastewater. Incineration of 1,4-dioxane-containing distillates can reduce 1,4-dioxane concentrations by 90–98%[113].

[109] ITRC (2021). Remediation and Treatment Technologies 1,4-Dioxane. Available at: https://14d-1.itrcweb.org/wp-content/uploads/2021/02/14DX-Remediation-2-12-Version-1.pdf

[110] Isaka et al. (2016). Biological wastewater treatment of 1,4-dioxane using polyethylene glycol gel carriers entrapping Afipia sp. D1. J Biosci Bioeng., 121(2), 203-208.

[111] American Water Chemicals, Inc. (2024). Advanced Oxidation Processes. Available at: https://www.membranechemicals.com/water-treatment/advanced-oxidation-plants/

[112] Barndõk H, Cortijo L, Hermosilla D, Negro C and Blanco A (2014) Removal of 1,4-dioxane from industrial wastewaters. Journal of Hazardous Materials, 280, 340-347. Available from: http://dx.doi.org/10.1016/j.jhazmat.2014.07.077

[113] Rüdel H, Körner W, Letzel, T. et al (2020) Persistent, mobile and toxic substances in the environment: a spotlight on current research and regulatory activities. Environ Sci Eur 32, 5. Available from: https://doi.org/10.1186/s12302-019-0286-x

APPENDIX 6 CONSULTATION SYNOPSIS

This Appendix provides a more detailed presentation of the stakeholder consultation activities described in Appendix 1 that were carried out as part of this Study. It outlines the consultation strategy and analysis methodology and provides a summary of the key outcomes of the consultation activities.

The aim of the consultation was to gather evidence and opinion on the restriction scenarios under consideration and their likely impacts. The stakeholder consultation was performed by Ricardo consultants, in collaboration with CESIO. In order to obtain detailed information on the potential impacts on the proposed restriction, two surveys were launched: one with surfactant manufacturers and importers and one with downstream users of surfactants which were hosted on Alchemer. These surveys were launched on 31st October 2023 and closed on 16th February 2024.

A6.1 STAKEHOLDER PARTICIPATION

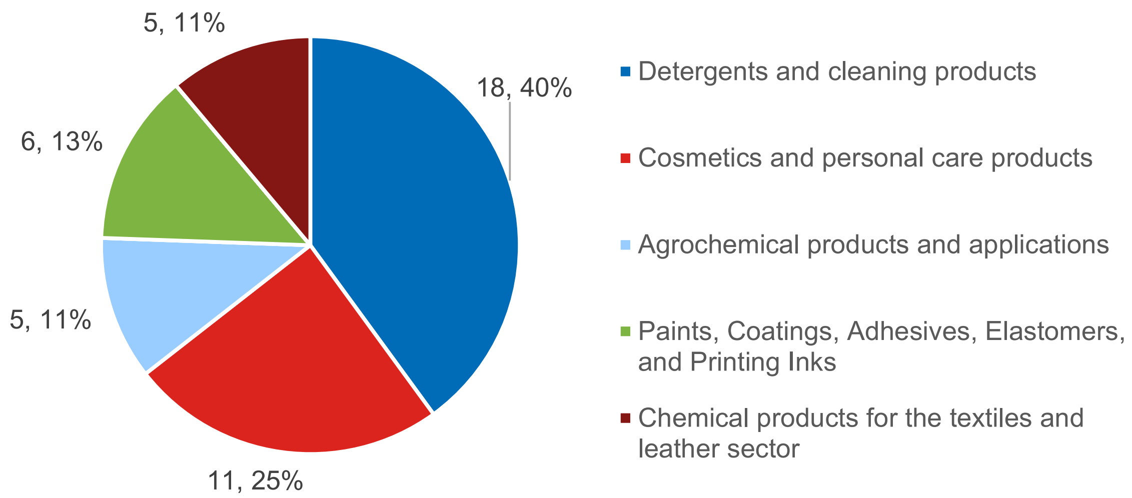
Stakeholders were divided into groups: 1) Manufacturers and Importers of surfactants of surfactants and 2) Downstream users (DU) of surfactant products. The DU sectors considered for the survey were as follows: Detergents and cleaning products; Cosmetics and personal care products; Agrochemical products and application; Lubricant products; Paints, Coatings, Adhesives, Elastomers, and Printing Inks; Pharmaceutical products; Construction products; and Chemical products for the textiles and leather sector. However, the sectors with insufficient responses were excluded from the scope during the methodological stocktake, ultimately resulting in five downstream user sectors considered in scope of the Study: *'Detergents and cleaning products'; 'Cosmetics and personal care products'; 'Agrochemical products and applications'; 'Paints, Coatings, Adhesives, Elastomers, and Printing Inks'; and 'Chemical products for the textiles and leather sector'*. The Table below summarises the number of participants for each of the stakeholder groups.

Table _A 12 Stakeholder participation

Stakeholder group	Number of participants
Manufacturers and importers of surfactants	40
Downstream users	45

The breakdown of the 45 downstream user respondents by downstream user sector is presented in the Figure below.

Figure A 5 Breakdown of the downstream user respondents by downstream user sector.



In terms of size of the companies which participated in the survey, the majority of them were large companies with a very limited representation of small and medium companies in the sample. The Table below provides a breakdown of the respondent companies for each stakeholder group by their size.

Table _A 13 Size of companies who participated in the consultation

Stakeholder group	Small and Medium enterprises	Large enterprises
Manufacturers and importers of surfactants	5	35
Downstream users	7	38

A6.2 METHODOLOGY

Following the closure of the stakeholder survey, the submitted responses were analysed using Ricardo's in-house analysis tools (Microsoft Excel). The analysis considered the overall responses of the stakeholders and also by stakeholder type, with the different options highlighted as relevant.

- Step 1: The raw data which comprised the survey responses was downloaded, cleaned and encoded to enable effective analysis, and so that meaningful outputs could be produced from the responses.
- Step 2: A comprehensive distributional analysis was performed for each question in the survey. This involved an examination of the distribution of responses to identify any notable patterns, trends, or outliers. Medians, modes, 25th and 75th percentile estimates, minima and maxima were also considered.
- Step 3: The estimates of the impacts were derived by averaging the impacts reported in the survey responses. Both simple and weighted averages were estimated to ensure that the views of larger respondents were given proportional consideration.
- Step 4: External evidence was also gathered from annual reports and industry reports (e.g. CESIO statistics) to contextualise validate the assumptions made within the analysis and also confirm coherence with broader industry trends. Follow-ups were performed to confirm responses where discrepancies were observed. Key stakeholders were engaged in dialogue to delve deeper into specific responses.

Responses to open text questions or position papers/attachments provided by respondents were also reviewed and/or analysed, also split by stakeholder type and issue/interest. These questions were systematically checked for overlaps to detect any coordinated responses. Each open text reply was checked against all other open text responses for their textual similarity by considering the cosine similarity of all answers against all other answers.

A6.3 SUMMARY OF FINDINGS

Key findings of opinions and evidence for the restriction scenarios under consideration and impacts are outlined below by survey section.

Baseline

Within the survey, a number of questions were asked in order to develop a quantitative baseline comprising production in the EU-27, imports into the EU-27, exports out of the EU-27 and employment. The following tables provide a summary of the baseline values by stakeholder including production, imports, exports, and employment.

Overall, the responses for manufacturers and importers of surfactants represents over 80% of the market in terms of in 2021. The table below provides the aggregated responses for these respondents.

Table _A 14 Baseline values across multiple indicators for manufacturers and importers of surfactants

Variable	'000 Tonnes	Manufacturers and importers of surfactants
Production in the EU-27 ('Sold production') (N=36)	4,000	€7,500 million
Imports into the EU-27 (N=18)	165	€250 million

Variable	'000 Tonnes	Manufacturers and importers of surfactants
Exports out of the EU-27 (N=36)	800	€1,500 million
Employment (N=40)	-	9,000 FTE

For the downstream user markets, the responses cover over 40% of the five specific downstream user markets in terms of sales values and over 20% in terms of employment for 2021. The table below provides the aggregated responses for these respondents.

Table _A 15 Baseline values across multiple indicators for downstream user markets of surfactants

Variable	Downstream users
Production in the EU-27 ('Sold production') (N=43)	€53,000 million
Imports into the EU-27 (N=37)	€5,100 million
Exports out of the EU-27 (N=43)	€8,900 million
Employment (N=43)	97,000 FTE

To characterise the baseline scenario, the businesses were asked about their expected **evolution of key economic variables over the next 15 years if the proposed REACH restriction on 1,4-dioxane was not implemented**. Both manufacturers and importers and downstream users of surfactants estimated that in this case, employment, turnover, capex, opex and R&D expenditure would increase over the next 15 years. Overall, the magnitude of these expected increases was similar or slightly larger for manufacturers and importers of surfactants as compared to downstream users.

Business impacts

Within the survey, respondents were asked several questions regarding the potential business impacts of the two restriction scenarios under consideration for their portfolio. This included questions about their affected portfolio of surfactant products that contained levels of 1,4-dioxane subject to restriction (1 or more ppm under RS1 and 10 or more ppm under RS2). In addition, respondents were asked about the proportion of their affected portfolio they could substitute or replace with alternatives.

Manufacturers and importers of surfactants (N=37) reported that around 70% of their sales turnover came from products containing 1 or more ppm of 1,4-dioxane, and around 40% for of their sales turnover came from products containing 10 or more ppm of 1,4-dioxane. Downstream users (N=39) reported that around 60%-88% of their sales (dependent on the sector) contained and/or required surfactants with 1 or more ppm of 1,4-dioxane whereas around 40%-63% of their sales (dependent on the sector) contained and/or required surfactants with 10 or more ppm of 1,4-dioxane. These results are presented in the Table below.

Table _A 16 Average proportion of sales for segments of the surfactants value chain in the EU-27 associated with surfactants containing more than 0 ppm of 1,4-dioxane by levels of 1,4-dioxane (% of sales turnover)

Segment of value chain	0 ppm	>0 - <1 ppm	≥1 - < 10 ppm	≥10 ppm
Manufacturers and importers of surfactants (N=37)	~15%	~15%	~30%	~40%
Detergents and cleaning products (N=13)	~10%	~25%	~15%	~50%
Cosmetics and personal care products (N=11)	~5%	~35%	~30%	~30%
Paints, Coatings, Adhesives, Elastomers, and Printing Inks (N=5)	~25%	~5%	~30%	~40%

Segment of value chain	0 ppm	>0 - <1 ppm	≥1 - < 10 ppm	≥10 ppm
Chemical products for the textiles and leather sector (N=5)	~20%	~10%	~25%	~45%
Agrochemical products and applications (N=5)	~5%	~7%	~25%	~63%

The survey asked respondents to elaborate if they had any **experience with the development of new surfactant products**. Around 85% of the manufacturers and importers of surfactants (N=35) said that they had such experience. Similarly, around 80% the downstream user respondents (N=36) said they had such experience. On average, the lead times for bringing new or adjusted products to market varied between 3-5 years for manufacturers and importers of surfactants, the detergents and cleaning products sector and the cosmetics and personal care products sector, 2-4 years for the chemical products for textiles and leather sector, 5-9 years for the paints, coatings, adhesives, elastomers, and printing inks sector and 9-13 years for the agrochemical products and applications sector.

The respondents with experience in the development of alternatives were further asked about the types of hurdles that they faced when bringing new surfactant products to market, and also the types of **hurdles they expected to face when bringing to market alternative or new products that accommodate the REACH restriction scenarios**. In response to these questions, more than 95% of upstream and downstream respondents said that they had faced some form of hurdles when bringing alternative or new surfactant products to market, with worsened product performance, regulatory costs and relatively higher operating costs being the most common. Respondents also expected to face similar hurdles when bringing new products to market which accommodate the REACH restriction scenarios. Specifically, 95% of manufacturers and importers of surfactants who responded (N=39) expected to face relatively higher operating costs, around 75% expected high regulatory costs and complex and difficult-to-meet legal requirements (including standards), more than 70% expected worsened product performance (e.g., durability) and around 60% expected long lead times. For downstream user respondents (N=41), more than 75% expected to face worsened product performance and long lead times, more than 70% expected to face complex and difficult-to-meet legal requirements, high regulatory costs and relatively higher operating costs.

Manufacturers and importers of surfactants also provided feedback suggesting that it would be more feasible, technically and economically, to achieve a 1,4-dioxane concentration level of less than 10 ppm using existing removal technologies and/or adjusting the surfactant products. However, reducing the level of 1,4-dioxane to less than 1 ppm would be more difficult and/or unviable, with uncertain technical/ economic viability and requiring additional time and/or expenditure. **Overall, substitution rates are lower under RS1 than RS2 and therefore, the impact on the surfactants market is greater under RS1 than RS2**. In the upstream surfactants market, on average, 25% of the affected portfolio of products in RS1 and 70% of the affected portfolio of products in RS2 could potentially be replaced with substitutes and/ or adjusted with no or low levels of 1,4-dioxane. The Table below summarises these responses.

Table _A 17 Average proportion of affected products with potential 'substitutes' for manufacturers and importers of surfactants (% of affected portfolio in sales terms)

Segment of value chain	RS1	RS2
Surfactants (N=32)	25%	70%

Further downstream in the surfactants value chain, **the proportion of affected surfactant products which have potential alternatives was observed to vary depending on the downstream user sector**. On average, the cosmetics and personal care products sector reported the highest levels of potential substitution whereas the chemical products for textiles and leather sector reported the lowest levels of potential substitution. It must be noted that downstream user respondents were not asked about substitution and product adjustments separately for each restriction scenario and the distribution of responses, along with expert input, was used to derive estimates of the potential costs of substitution under each restriction scenario (refer to Section 4.1.1.2). The Table below summarises the responses by downstream user sector.

Table _A 18 Average proportion of affected products with potential 'substitutes' for manufacturers and importers of surfactants (% of affected portfolio in sales terms)

Indicator	Detergents and cleaning products (N=14)	Cosmetics and personal care products (N=10)	Paints, Coatings, Adhesives, Elastomers, and Printing Inks (N=5)	Chemical products for the textiles and leather sector (N=5)	Agrochemical products and applications (N=5)
Average proportion of affected products with potential 'substitutes' (% of affected portfolio in sales terms)	90%	95%	75%	45%	90%

When asked about whether they were aware of the **cost, performance, risks to human health and/or risks to the environment** of these alternatives, both manufacturers and importers of surfactants and downstream users said that on average, these alternative products would have a higher manufacturing cost/ price and lower performance while maintaining similar levels of human health risks and environmental risks.

Survey respondents were also asked to quantify the **additional one-off or capital costs and annualised recurring or operating costs of the alternatives over the next 15 years** across the two restriction scenarios under consideration. Overall, manufacturers and importers of surfactants said that the additional costs were expected to be highest under restriction scenario 1, followed by restriction scenario 2. These are presented in the Table below.

Table _A 19 Total additional costs of 'substitution' for the sample of manufacturers and importers of surfactants

Additional costs of 'substitution'	RS1	RS2
One-off costs (N=32)	€2,600 million	€2,000 million
Recurring costs (N=34)	€12,500 million	€12,300 million

Downstream user respondents also reported high additional costs of substitution and adjustments of surfactant products with no or low levels of 1,4-dioxane over the next 15 years. These are presented in the Table below. It must be noted that downstream users were not asked about these costs separately for each restriction scenario and the distribution of responses was used to derive estimates of the potential costs of substitution under each restriction scenario (refer to Section 4.1.1.2).

Table _A 20 Total additional costs of 'substitution' for the sample of downstream users by sector

Indicator	Detergents and cleaning products (N=11)	Cosmetics and personal care products (N=8)	Paints, Coatings, Adhesives, Elastomers, and Printing Inks (N=5)	Chemical products for the textiles and leather sector (N=5)	Agrochemical products and applications (N=5)
One-off costs	€250 million	€200 million	€100 million	€40 million	€140 million
Recurring costs	€480 million	€830 million	€10 million	€20 million	€80 million

Please note that these absolute figures and their size depend on the sample and type of respondents. For analysis and extrapolation, these were employed to estimate potential costs as a ratio of turnover value, the ratios were analysed in line with the usual methods (distribution analysis, etc), and the final estimates were used as a way to estimate the potential compliance/adjustment costs for the markets in scope.

Finally, manufacturers and importers were asked to comment on how the **adoption of the REACH restriction scenarios might affect their organisation's turnover (or business activity) and employment levels over the next 15 years** (cumulatively), when compared to 2021 levels, if they responded as they had outlined within the survey. Overall, respondents expected negative impacts on business and employment, with the most adverse under restriction scenario 1, followed by restriction scenario 2, as presented in the Table below.

Table _A 21 Average turnover and employment impacts (cumulative over the period when compared to the baseline) of the adoption of the REACH restriction scenarios for manufacturers and importers of surfactants

Indicator	RS1	RS2
Impact on turnover (N=36)	Decrease significantly over the period (more than -50% to -95%)	Decrease moderately over the period (more than -25% to -50%)
Impact on employment (N=37)	Decrease significantly over the period (more than -50% to -95%)	Decrease moderately over the period (more than -25% to -50%)

Downstream users also expected negative impacts on turnover over the next 15 years (cumulatively), when compared to 2021 levels, if the REACH restriction on surfactants with 1,4-dioxane is adopted and they responded as they had outlined within the survey. The degree of negative impacts varied by downstream user sector, presented in the Table below.

Table _A 22 Average turnover impacts (cumulative over the period when compared to the baseline) of the adoption of the REACH restriction scenarios for the sample of downstream users by sector

Indicator	Detergents and cleaning products (N=12)	Cosmetics and personal care products (N=8)	Paints, Coatings, Adhesives, Elastomers, and Printing Inks (N=6)	Chemical products for the textiles and leather sector (N=5)	Agrochemical products and applications (N=5)
Impact on turnover	Decrease moderately over the period (more than -25% to -50%)	Decrease slightly over the period (more than -5% to -25%)	Decrease significantly over the period (more than -50% to -95%)	Decrease moderately over the period (more than -25% to -50%)	Decrease moderately over the period (more than -25% to -50%)

Other impacts

The final section of the survey widened the scope to consider other dimensions of impact of the restriction scenarios, concerning knowledge of wastewater treatment plants and their ability to remove 1,4-dioxane as well as global competitiveness and the availability of products pertaining to the surfactants value chain.

Manufacturers and importers of surfactants had limited evidence or knowledge of wastewater treatment plants and the extent to which they can remove 1,4-dioxane from surfactant manufacturing or other related waste. Only 49% of respondents (N=39) said that they had knowledge of the wastewater treatment plants and their ability to remove 1,4-dioxane from waste. Moreover, on average, respondents with such knowledge (N=16) said that wastewater treatment plants are only able to remove the 1,4-dioxane from the waste generated by surfactant product manufacturing or related activities prior to any discharge into the environment to some extent.

Downstream users were even more limited in terms of their knowledge of wastewater treatment plants and the extent to which they can remove 1,4-dioxane from surfactant manufacturing or other related waste, as only 15% of respondents (N=40) said they had such knowledge or evidence. Of the few that had such knowledge (N=6), there was variation in their views on the extent to which wastewater treatment plants can remove the 1,4-dioxane from the waste generated by surfactant product manufacturing or related activities prior to any discharge into the environment, as the responses varied from 'limited extent' to 'large extent'.

Finally, the questionnaire investigated **impacts of the proposed restriction on global competitiveness of the surfactants industry and the availability of surfactants in the EU-27** over the next 15 years. On average, manufacturers and importers of surfactants expected negative impacts across restriction scenarios, with severe adverse impacts on the availability of surfactants under restriction scenario 1. The Table below presents the responses from the survey in further detail.

Table _A 23 Average impacts of the adoption of the REACH restriction scenarios on global competitiveness and the availability of surfactants over the next 15 years for manufacturers and importers of surfactants

Indicator	RS1	RS2
Impact on global competitiveness (N=36)	Negative effect	Mildly negative effect
Availability of surfactants in the EU (N=37)	Severely negative effect	Mildly negative effect

Downstream users also expected negative impacts of varying degrees on global competitiveness of their industries and the availability of products in the EU-27 over the next 15 years. These effects were expected to be the least adverse for the 'cosmetics and personal care products' industry and the most adverse for the 'chemical products for the textiles and leather sector' industry, as presented in the Table below.

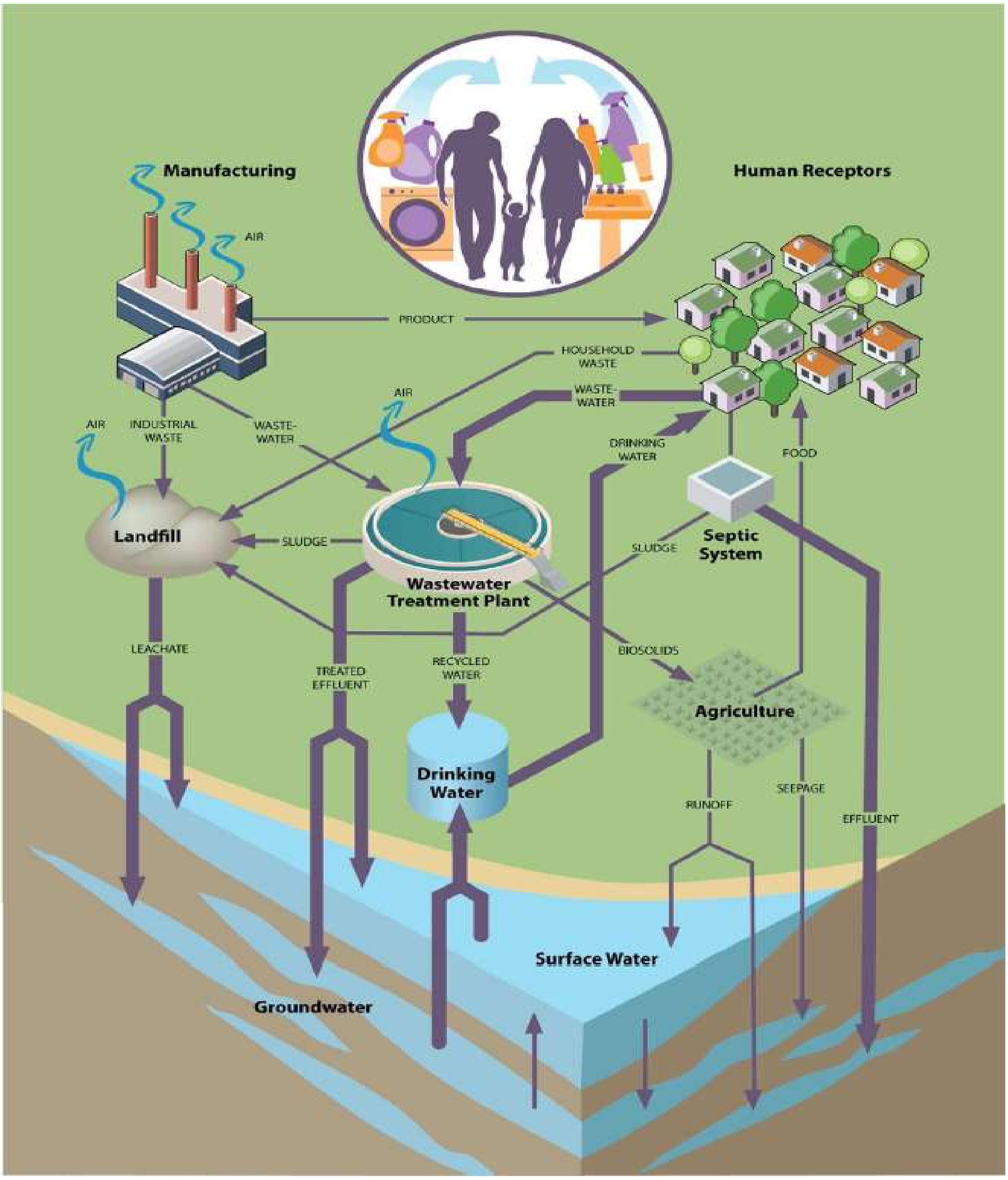
Table _A 24 Average impacts of the adoption of the REACH restriction scenarios on global competitiveness and the availability of products over the next 15 years for downstream user sectors

Indicator	Detergents and cleaning products (N=16)	Cosmetics and personal care products (N=10)	Paints, Coatings, Adhesives, Elastomers, and Printing Inks (N=6)	Chemical products for the textiles and leather sector (N=5)	Agrochemical products and applications (N=5)
Impact on global competitiveness	Negative effect	Mildly negative effect	Negative effect	Negative effect	Negative effect
Availability of products in the EU	Negative effect	Mildly negative effect	Negative effect	Severely negative effect	Negative effect

APPENDIX 7 ENVIRONMENTAL IMPACTS

As described in Sections 3.1.4 and 4.3, surfactants and their products with 1,4-dioxane as an impurity can release 1,4-dioxane into the environment, particularly to water compartments such as ground water, surface water and drinking water, during their manufacture and use. The following figure illustrates the potential pathways for 1,4-dioxane for the manufacturing and use of consumer products (such as detergents and cleaning products) with water the main environmental compartment for 1,4-dioxane releases.

Figure A 6 Fate and transport of 1,4-dioxane in the environment.



Source: Doherty A-C, Lee C-S, Meng Q, Sakano Y, Noble AE, Grant KA, Esposito A, Gobler CK and Venkatesan AK (2023). Contribution of household and personal care products to 1,4-dioxane contamination of drinking water. Current Opinion in Environmental Science & Health, 31:100414 used under Creative Commons CC-BY licence[114]. The bold arrows show the urban water cycle; however, these are not related to concentrations of 1,4-dioxane for each pathway scenario.

[114] CCC RightsLink (2024). Contribution of household and personal care products to 1,4-dioxane contamination of drinking water. Available from https://s100.copyright.com/AppDispatchServlet?publisherName=ELS&contentID=S2468584422000897&orderBeanReset=true

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