ANALYSIS OF ALTERNATIVES

and

SOCIO-ECONOMIC ANALYSIS

PROVIDED AS COMMENTS TO THE PUBLIC CONSULTATION ON THE REACH RESTRICTION PROPOSAL ON PER- AND POLYFLUOROALKYL SUBSTANCES (PFAS)

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Date:	22.09.2023

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LIST OF ABBREVIATIONS

AE	Aqua Europa
AFIR	Alternative Fuels Infrastructure Regulation
AoA	Analysis of Alternatives
ATEX	Equipment for Potentially Explosive Atmospheres
CH_4	Methan
CNG	Compressed Natural Gas
CO_2	Carbon Dioxide
DGMT	German Society for Membrane Technology
DME	Dimethyl Ether
EBIT	Earnings Before Interest and Tax
EC	European Commission
ECHA	European Chemicals Agency
EEA	European Economic Area
EN	European Standard
EPDM	Ethylene-propylene-diene(monomer) Rubber
EU	European Union
FAME	Fatty Acid Methyl Esters
FEP	Fluorinated ethylene propylene
FFKM	Perfluoroelastomers
figawa	German Association of Companies for Gas and Water Technologies
FKM	Fluoro Rubbers
FP	Fluoropolymers
FTE	Full time Equivalent
GAR	Gas Appliances Regulation
GLF	Gas and Liquid Fuels
H_2	Hydrogen
H_2S	Hydrogen Sulfide
He	Helium
HVO	Hydrotreated Vegetable Oils
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization

LCI	Labour Cost Index
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
LSR	Liquid Silicone Robber
MID	Measuring Instruments
MPa	Megapascal
MPTFE	Polytetrafluoroethylene
N_2	Nitrogen
NBR	Nitrile Butadiene Rubber
NPV	Net Present Value
OEM	Original Equipment Manufacturer
OIML	International Organization of Legal Metrology
PCTFE	Polychlorotrifluoroethylene
PED	Pressure Equipment Directive
PFA	Perfluoroalkoxy alkane
PFAS	Per-and Polyfluoroalkyl Substances
PFPE	Perfluoropolyethers
PLC	Polymer of Low Concern
PPS	Polyphenylene Sulfide
PTFE	Polytetrafluoroethylene
PU	Polyurethane
PVDF	Polyvinylidene Fluoride
R&D	Research and Development
RO	Restriction Option
SCFP	Side-chain Fluorinated Polymers

SUMMARY

The present document is part of the submission of figawa e.V., DGMT and AE for the public consultation on the PFAS restriction proposal.

It describes the use of fluoropolymers (FPs) in products used for Gas and Liquid Fuels (GLF) applications, which describe the use of highly flammable, combustible gases and short-chain molecules with high energy densities. The most commonly used GLFs are natural gas (mainly composed of methane, CH_4), compressed natural gas (CNG), liquefied natural gas (LNG), liquefied petroleum gas (C3-C4 alkanes, LPG) and liquid mineral oils. In addition, renewable GLFs, such as hydrotreated vegetable oil (HVO), fatty acid methyl esters (FAME), dimethyl ether (DME), and hydrogen (H_2) in natural gas and pure H_2 are gaining more relevance as energy carrier. Hence, storage, transport and measuring (for billing) of all these energy carriers is included in GLF applications.

Combustion technology is of utmost importance in providing heat and energy for industrial, private and commercial purposes. Ensuring the safe and efficient operation of these applications relies on precise control and measurement of critical parameters. Crucial aspects include the regulation of internal pressure and gas metering for billing purposes (legal requirement), achieved through the use of fluoropolymers-based components. These fluoropolymers-based parts play a vital role in preventing overpressure build-up, safeguarding against potential environmental and economic disasters in the case of gas or liquid fuel releases.

Fluoropolymers-based sealings, including materials like FKM, PTFE, and PVDF, are currently indispensable in these installations. Their exceptional chemical and temperature resistance, along with robust mechanical properties, make them the preferred choice, as no other materials currently match their performance, lifetime and meet the stringent standards required for these critical applications. Fluoropolymers-based sealings also hold significant importance in the private, residential, commercial and industrial sectors in gas heating / applications, where they serve to prevent leaks and potential accidents.

FPs are high-performance materials with exceptional properties, such as chemical resistance, thermal stability, low flammability, material flexibility and anti-friction / gliding properties. There is no other available material that combines this wide range of functions and therefore no suitable alternatives exist at this time. Hence, figawa primarily supports an exemption of fluoropolymers by way of a time-unlimited derogation for the Gas and Liquid Fuels applications and distribution or at least the longest derogation period to perform the research necessary to find and implement alternatives that meet high standards, which would certainly require more than 20 years.

In summary, the consequences of a PFAS restriction, as outlined by the socioeconomic evaluation, amount to roughly 515.10 million Euros (NPV 2025) or 21.01 million Euros annually over a 45-year period. While this analysis predominantly focuses on input from figawa members and addresses issues related to gas and fuel shortages due to lack of impacted GLF components, it is crucial to highlight the far-reaching repercussions that a restriction, without the desired exemption, could have on the entire EEA society. Fast CO2-reduction by replacing hydrocarbons against hydrogen H_2 would become with a high probability impossible.

1. Introduction

This comment is submitted in the name of figawa e.V.[1], the German association of companies for gas and water technologies supported by DGMT e.V.[2] (German society for membrane technology) and Aqua Europa AE[3]. Our members provide products and services for the utilisation and distribution of gas and liquid fuels as well as the distribution and the treatment of drinking water and water for industrial and municipal purposes including wastewater and pool water treatment.

figawa has more than 275 member companies, which generate around 34 billion Euros of revenues annually. As an industry association, we bring together interests and advocate for standardized regulations and legislative processes to ensure long-term legal and planning certainty for all market participants. With our expertise, technology, and open dialogue, we aim to drive progress and innovation in our industries in the EU. Cross-cutting issues, as well as needs and requirements of our members are addressed in our industry aligned sector coordination groups.

The figawa members have aligned into three clusters based on the presence of PFAS in their product portfolio and applications to provide comments for the PFAS restriction proposal. These clusters are:

1. Water treatment (drinking water, wastewater, industrial water, water reuse and pool water)
2. Water supply (public infrastructure, water distribution in buildings and water measurement and distribution of thermal energy) and
3. Gas & liquid fuels (application and distribution)

To fulfil their responsibility of providing millions of private households, municipalities and industry with resources such as gas, liquid fuels, and water, our members depend on a variety of fluoropolymers-based technical components, all of which with high requirements towards their mechanical and chemical properties. This does not only guarantee a functioning infrastructure with an enormous economic impact on the European society but also the very safety of the European population.

It is important to note that figawa members are not manufacturers of per- and polyfluoroalkyl substances (PFAS) or polymer PFAS raw material. They mainly assemble end-products from components and are only a part of the supply-chain. They are thus not directly involved in the development process of PFAS-free alternatives, which exhibit the complex set of physicochemical properties required for their products. It is additionally worth noting that due to the members' position in the supply chain, the exact composition of components in relation to PFAS is often unknown to them.

Under this premise, the members identified that polymeric PFAS are of extraordinary importance for the safe and durable operation of their products. Polymeric PFAS may be categorized into three groups: Fluoropolymers (FPs), perfluoropolyethers (PFPEs), and side-chain fluorinated polymers (SCFPs) (ECHA, 2023) (Korzeniowski, et al., 2023). Of these three classes, FPs including fluoroplastics (e.g. polytetrafluoroethylene (PTFE) or polyvinylidene fluoride (PVDF)) and fluoroelastomers (e.g. fluorine rubber (FKM)) are the most important for the figawa members. This is also reflected by the first comment

[1] https://figawa.org/
[2] https://www.dgmt.org/the-dgmt.html
[3] https://aqua-europa.eu/

submitted by figawa[4], in which a time-unlimited derogation for FPs was proposed. The importance of FPs for the members' products becomes apparent when analysing the components used for the manufacture of their end-products (see section 2.1).

FPs have very high molecular weight (Korzeniowski, et al., 2023) and show excellent thermal, chemical, photochemical, oxidative, hydrolytic and biological stability with low flammability, neutral electrical charge and resistance to degradation. No reactive groups are present in the structure of fluoropolymers. They are characterized by a carbon-only polymer backbone with F atoms directly attached to it, a unique feature in the chemical space. FPs do not bioaccumulate, are not mobile and fulfil the Polymer of Low Concern (PLC) criteria (OECD, 2009).

The following report addresses the products and the respective applications for '**Cluster 3: Gas and Liquid Fuels**'. It is the consolidated information of figawa's members and aims to represent the European Gas & Liquid Fuels sector. The report provides an overview on where FPs are present and what functionalities are provided by them. In addition, potential alternatives are discussed in section 2 and a hypothetical substitution timeline is presented in section 3. Socio-economic impacts of a potential restriction of PFAS are described in section 4.

1.1. Gas & Liquid Fuels

Gas & Liquid Fuel (GLF) applications describe the use of highly flammable, combustible gases and short-chain liquids with high energy densities. The most commonly used GLFs are natural gas (mainly composed of methane, CH_4), compressed natural gas (CNG), liquefied natural gas (LNG), liquefied petroleum gas (C3-C4 alkanes, LPG) and liquid mineral oils. In addition, renewable GLFs, such as hydrotreated vegetable oil (HVO), fatty acid methyl esters (FAME), dimethyl ether (DME), and hydrogen (H_2) in natural gas and pure H_2 are gaining more relevance as energy carrier. Hence, storage, transport and measuring (for billing) of all these energy carriers is included in GLF applications.

Due to their properties, they are used as energy carriers for a wide range of applications. While in many countries across the globe, GLFs are still in use in private households for cooking and heating, in the European Union the main applications are for industrial uses, power generation, as a motor fuel and for other industrial applications. **GLFs are thus essential for the European energy supply**.

The transport and storage of GLFs always requires pressurised systems. Hence, any pipeline, vessel or other equipment used must show excellent pressure resistance. Pressures inside transport pipelines and pressure vessels can range from 10-200 bar. Combined with their physical-chemical properties, the transport and storage of GLFs pose a safety concern. LNG and LPG sites are for example subject to the EU Seveso Directive (Directive 2012/18/EU), as any impact on the leak tightness of equipment can result in spilling of GLFs and consequently their rapid evaporation and very often catastrophic combustion.

To ensure the proper functionality of GLF applications there are several crucial parameters to control and measure. For example, it is important to control the internal pressure, for which pressure regulators and compressors are installed that contain fluoropolymers-based parts. This equipment safely prevents the build-up of overpressure which could

[4] Comment 4433 from 2023-06-02 accessible via https://echa.europa.eu/documents/10162/8d917581-7faf-4e1a-26d4-073d52b3406e (last accessed 2023-09-15)

result in an ecological and economic catastrophe in case there is a release of GLF into the environment.

1.2. EU Regulations / directives

Gases and Liquid Fuels are critical elements of the EU's energy infrastructure. Hence, several regulations and directives exist to provide a certain level of safety and to ensure the future availability of these energy sources. In the following, a few relevant policies are presented.

Regulation (EU) 2016/426 on appliances burning gaseous fuels (EUR-Lex, 2016)

The Gas Appliances Regulation (GAR) clarifies the requirements each gas appliance and fitting have to fulfil. It "also introduces harmonised content for the communication of gas supply conditions in EU countries, enabling the design and construction of safe and correctly performing products" (European Commission, n.d. b). The term fitting includes components, such as regulating, controlling and safety devices and sub-assemblies thereof. However, products designed for industrial processes on industrial sites and gas meters are excluded from the GAR.

Annex I of the GAR specifies the essential requirements that appliances need to fulfil to "present no danger to persons, domestic animals or property, when normally used". The objective of the requirements is to ensure "a high degree of energy efficiency and of health and safety protection". Annex I further states that materials "for appliances or fittings shall be appropriate for their intended purpose and shall withstand the mechanical, chemical and thermal conditions to which they will foreseeably be subjected".

The GAR further specifies the assessment procedure of EU type examination and respective certification. Any intended changes of components of the products, which have been tested and certified according to the GAR must be shown to the notified body. The notified body will then "evaluate any proposed changes and decide whether the modified quality system will continue to satisfy the requirements (…) or whether a reassessment is necessary". This is important to highlight, as it is relevant for the provision of spare parts in case of substitution (see section 3 for further details).

Once the assessment procedure has been applied successfully the conformity to the regulation can be declared by the manufacturer and the CE mark can be attached to the product.

Pressure Equipment Directive (PED) 2014/68/EU (EUR-Lex, 2014a)

The Pressure Equipment Directive (PED) clarifies the design, manufacturing and conformity assessment for pressure equipment having a maximum pressure of greater 0,5 bar.

Pressure equipment such as gas pressure regulators, safety shut-off devices and flow control valves, are an essential part of a continuous and safe gas supply also for industrial processes and industrial sites.

In order to obtain the CE mark for the product each of the pressure equipment has to undergo a conformity assessment procedure.

Annex I of the PED specifies the essential safety requirements that must be fulfilled to "present no danger to persons, domestic animals or property, when normally used".

The impact of changing materials is analogue to the GAR (EU) 2016/426 as already described above.

Directive 2009/73/EC (Gas Directive) on common rules for the internal market in natural gas (EUR-Lex, 2022)

The Gas Directive aims to introduce common rules for the transmission, distribution, supply and storage of natural gas. It includes liquefied natural gas (LNG), biogas and gas from biomass. The Gas Directive is currently reviewed and revised as part of the "Hydrogen and gas markets decarbonisation package".

Regulation (EC) No 715/2009 on conditions for access to the natural gas transmission networks (EUR-Lex, 2009)

The Gas Regulation sets non-discriminatory rules for access conditions to natural gas transmission systems and facilitates the emergence of a wholesale market with a high level of security of supply in gas. The Gas Regulation is currently reviewed and revised as part of the "Hydrogen and gas markets decarbonisation package".

Directive 2014/94/EU on the deployment of alternative fuels infrastructure (EUR-Lex, 2014b)

The Directive aims to minimise dependence on oil by building an infrastructure for alternative fuels, such as refuelling points for natural gas (LNG and CNG) and hydrogen. It has been repealed, so that it can become a regulation instead of a directive (see AFIR).

Proposal for an Alternative Fuels Infrastructure Regulation (AFIR) (EUR-Lex, 2021a) (adopted in July 2023 (Directorate-General for Mobility and Transport, 2023))

One of the elements of the EU's goal of reducing net greenhouse gas emissions by 2030 ("Fit for 55") (European Commission, 2021) is to enhance the infrastructure for alternative fuels. Hence the proposed AFIR regulation sets "targets for electric recharging and hydrogen refuelling infrastructure for the road sector, for shore-side electricity supply in maritime and inland waterway ports, and for electricity supply to stationary aircraft" (European Commission, 2023).

Hydrogen and gas markets decarbonisation package

The Gas Directive and the Gas Regulation are revised under this package to ensure that the EU's energy and climate objectives under the Green Deal will be achieved. The package "enables the market to decarbonise gas consumption and puts forward policy measures required for supporting the creation of optimum and dedicated infrastructure, as well as efficient markets. It will remove barriers to decarbonisation and create the conditions for a more cost-effective transition. EU energy ministers reached a general approach on both proposals at the Energy Council, 28 March 2023. The legal acts can be formally adopted once an agreement is reached with the European Parliament" (European Commission, n.d. c).

The revisions will improve access and distribution of Hydrogen, as they aim to remove barriers and repurpose the existing natural gas infrastructure to be used for Hydrogen.

Directive 2014/34/EU (ATEX) Equipment and protective systems intended for use in potentially explosive atmospheres

Equipment which is used under a potentially explosive atmospheres has to fulfil the Directive 2014/34/EU. This Directive refers to a very huge set of standards (EN60079-xx and EN 80079-xx)_with requirements, regulations and test requirements for the devices itself and also for components of the devices.

Directive 2014/32/EU (MID) Making available on the market of measuring instruments

This MID directive specifies measuring instrument specific requirements for certain groups of instruments. Furthermore, it assigns responsibility to the manufacturer who places these measuring instruments on the market. Only measuring instruments that meet these MID requirements may be placed on the market and put into operation.

The above listed regulations, directives and initiatives illustrate the importance of GLF applications and their respective infrastructure in the EU. While the types of Gas and Liquid Fuels used may change in future, with an increased percentage of Hydrogen, the overall importance will not be affected. On the contrary, GLF applications will become even more critical for energy supply, and thus using high performance materials in GLF to ensure the safety of the population and the environment will continue to be essential.

2. ANALYSIS OF ALTERNATIVES

2.1. Fluoropolymers and Fluoropolymer-containing components

All submitted comments and documents describe the use of FPs for each cluster, respectively. Short-chain PFAS are not in scope of this submission.

Fluoropolymers-based sealings are currently without alternative in GLF installations. The most common fluoropolymers are FKM, PTFE and PVDF because of their highly favourable properties in regards of chemical and temperature resistance and mechanical properties. As of today, there are no alternative materials available that meet the required performance criteria and fulfil the high standards mandatory for these applications.

The sealings also play a crucial role in gas heating for the private, residential, commercial and industrial sectors to prevent leakage and thus accidents with potential explosion. A ban of fluoropolymers would entail huge costs for the substitution of all parts containing fluoropolymers, not to mention the costs for research and development to that end. Considering the high number of installations depending on fluoropolymers-sealings in today's infrastructure, substitution will take much more time than anticipated in the PFAS restriction proposal. Releases to the environment are negligible as production processes of fluoropolymers are technically designed to ensure prevention of dissipation of PFASs into the environment or will be improved where necessary. The finished products are employed in very controlled applications and are mounted and dismounted by professionals.

Table 1 provides an overview on which FPs are commonly used in GLF applications.

TABLE 1: OVERVIEW ON RELEVANT FPS AND THEIR FIELD OF APPLICATION IN GLF APPLICATIONS

Fluoropolymer used in GLF applications (non-exhaustive)	Fluoropolymer abbreviation	Associated components and end-products in which the fluoropolymer is used (non-exhaustive exemplification)
Fluororubbers	FPM / FKM	Sealant materials, Gas valves, gas pressure regulator and/or gas differential pressure regulator, safety shut-off valves, safety relief valves, volume control valves, gas control system, odorization system, membranes, rubber discs, sensors/flame detection devices, actuators
Polychlorotrifluoroethylene	PCTFE	Guide bushes
Perfluoropolyether	PFPE	Pressure monitors (contact passivation)
Polytetrafluoroethylene	PTFE	Gas valves, gas pressure regulator and/or gas differential pressure regulator, safety shut-off valve, safety relief valves, volume control valves, gas control system, sealant materials, guide elements, sliding components, gears, sensors/flame detection devices, actuators, bearings

	PTFE/FEP PTFE/MPTFE/PFA	Cable insulation Ball valves, needle valve
Polyvinylidene fluoride	PVDF PVDF/PCTFE/PTFE	Sealant materials

GLF products encompass a wide range of product groups, which consist of several individual components. The participants of this cluster reported to mainly produce valves (end-product group 3), peripheral systems, blowers and fans (end-product group 5), meters, sensors and analysis tools (end-product group 7). An illustrative distribution of end-product groups is depicted in Figure 1. A detailed description is provided in the Chemical Safety Report of this submission.

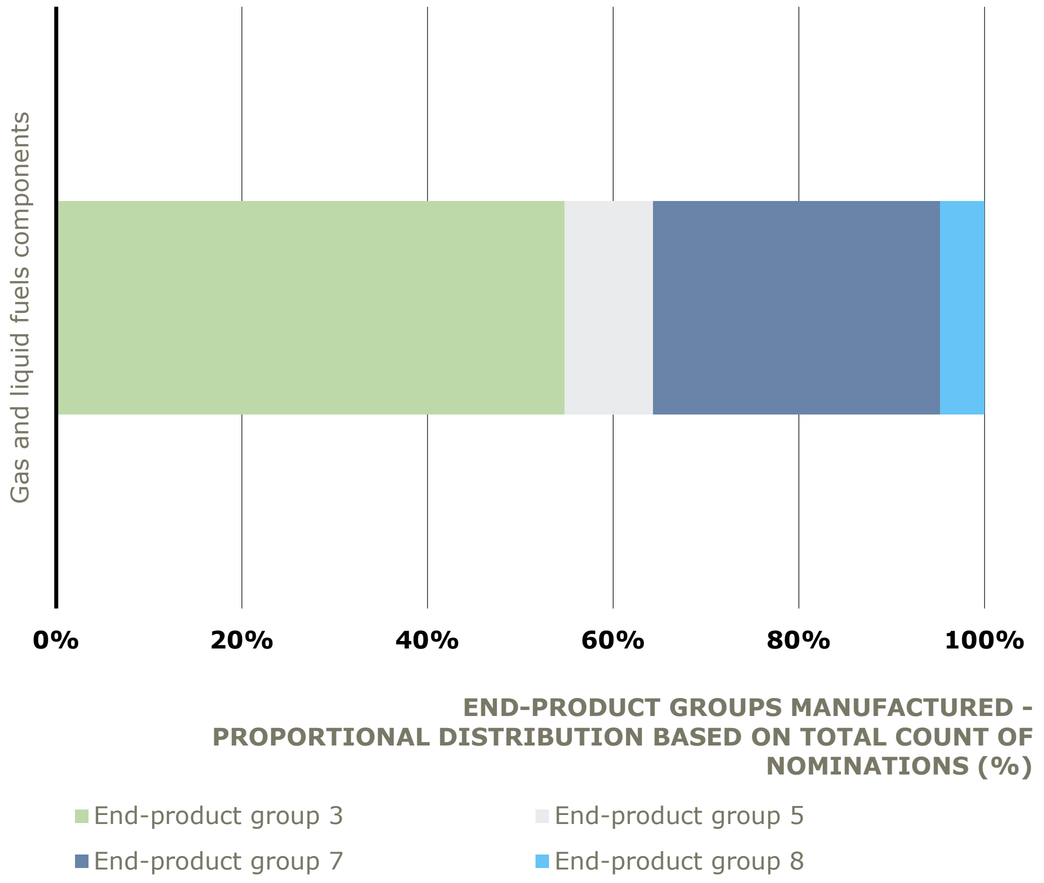

FIGURE 1: END-PRODUCT GROUPS MANUFACTURED WITHIN CLUSTER. GROUPS ARE DEFINED AS END-PRODUCT GROUP 3: BALL VALVES, VALVES, BUTTERFLY VALVES, FLOW/PRESSURE REGULATORS AND MONITORS, INJECTORS; END-PRODUCT GROUP 5: PERIPHERAL SYSTEMS, BLOWERS, FANS; END-PRODUCT GROUP 7: METERS, SENSORS, ANALYSIS TOOLS AND CONTROLS; END-PRODUCT GROUP 8: ACCESSORIES

Table 2 provides an overview on the component groups and the related end-product groups for which they are used. In consistency to the structure of the market – end-products are mostly assembled from various components – several FP-containing components are used per end-product group. Also, the same component group may be used in different end-product groups. For example, (O-)rings and other sealings as well as membranes are used in most end-product groups.

TABLE 2: FP-CONTAINING COMPONENTS AND USE IN END-PRODUCT GROUPS

Component group	Component details	End-product group			
		3	**5**	**7**	**8**
1	Spacers, anchors, caps, nozzles, fittings, ball valves, pump heads, hose connections/hoses, valves/valve seats	+	-	+	-
2	Use as processing aid, contact passivation, etc.	+	-	-	-
3	Electronic components (circuit boards, displays, injection units, flow meters, etc.), cables, batteries	+	+	+	+
4	Housings, containers, reactors, flame retardant plastic components	+	-	+	+
5	Paints, adhesives, potting compounds, binders, multi-component compounds, coatings	+	+	+	+
6	Membranes	+	+	+	+
7	O-rings, retaining rings, shaft seals, molded seals (gaskets)/(flat) sealings	+	+	+	+
8	Lubricants (greases, oils), lubricant coatings, bearings / slide bearings	+	+	+	+

It must be highlighted that the main group of products, which are the focus of the submission, are products/components in direct contact with gas and liquid fuels. These products/components must show high chemical inertness, temperature- and pressure resistance and provide further functions, such as material flexibility and gliding properties in order to provide the highest safety requirements.

However, this submission also includes products needed in GLF applications, such as control technology components (e.g. meters, sensors), which include FP-containing parts. While direct contact to gas and liquid fuels is usually not the case, these products are needed for the safe operation, flame detection / supervision and monitoring of GLF systems. In case of parameter exceedances, control technology provides the opportunity to initiate a safe shut down of the burner/ boiler and to sound alarm systems. Hence, they are included here in this submission.

The following figures illustrate components containing fluoropolymers as used in GLF systems as a non-exhaustive exemplification for the scope of the current report (Figure 2 to Figure 5).

[redacted]

FIGURE 2: DIAPHRAGM GAS METERS FOR GLF APPLICATIONS.

[redacted]

FIGURE 3: GAS VALVE IN USE FOR GLF APPLICATIONS.

FIGURE 4: PRESSURE CONTROL SYSTEM FOR GLF APPLICATIONS.

FIGURE 5: MEMBRANE WITH SEALANT RING.

2.1.1. The value chain of fluoropolymers

Combustion technology is of utmost importance in providing heat for residential, commercial and industrial purposes and the transformation into hydrogen energy storage. Ensuring the safe and efficient operation of these applications relies on precise control and measurement of critical parameters. One such crucial aspect is the regulation of internal pressure, achieved through the use of gas pressure regulators and compressors incorporating fluoropolymers-based components. These fluoropolymers-based parts play a vital role in preventing overpressure build-up, safeguarding against potential environmental and economic disasters in the case of gas or liquid fuel releases.

Fluoropolymers-based sealings, including materials like FKM, PTFE, and PVDF, are currently indispensable in these installations. Their exceptional chemical and temperature resistance, along with robust mechanical properties, make them the preferred choice, as no other materials currently match their performance and meet the stringent standards required for these critical applications. The material flexibility and low friction coefficient of FPs make them the most suitable materials for sealing and gliding applications. FP-based lubricants for example are used in valves and in other components with movable components. The lubricants enhance the gliding properties and significantly reduce wear-tear of components. FPs have an excellent lubrication effect even at high temperatures. They reduce wear-tear of components and prevent them from sticking to gas valves which may lead in reduced lifetime or to fire or explosion.

Fluoropolymers-based sealings also hold significant importance in the private, residential, commercial and industrial sectors in gas heating / applications, where they serve to prevent leaks and potential accidents. A ban on these components would lead to considerable costs for substituting the existing parts, and extensive research and development efforts would be necessary. Given the widespread use of fluoropolymers-based sealings in the current infrastructure, the process of substitution would be time-consuming and challenging.

Notably, fluoropolymers are designed to prevent the dispersion of PFASs into the environment during their production processes, and the finished products are used in controlled settings, professionally installed and maintained.

2.1.1.1. Key stakeholders within the value chain

A general overview of the value chain of fluoropolymer-based components used in GLF applications is depicted in Figure 6. The value chain comprises of **manufacturers producing fluoropolymers and downstream companies processing the respective substances** (e.g., into pellets and powders) for a variety of use applications. The processed fluoropolymers are further provided to **component manufacturers** which produce parts/components dependent on the substances as part of their portfolio. The respective fluoropolymer-based components are then sold to **Original Equipment Manufacturers (OEMs) of GLF technologies** that assemble these components into end products and/or equipment for numerous applications. These uses include mainly the **gas distribution and industry, power plants and providers of energy and heating, and industrial sectors which are the main gas and energy consumers**.

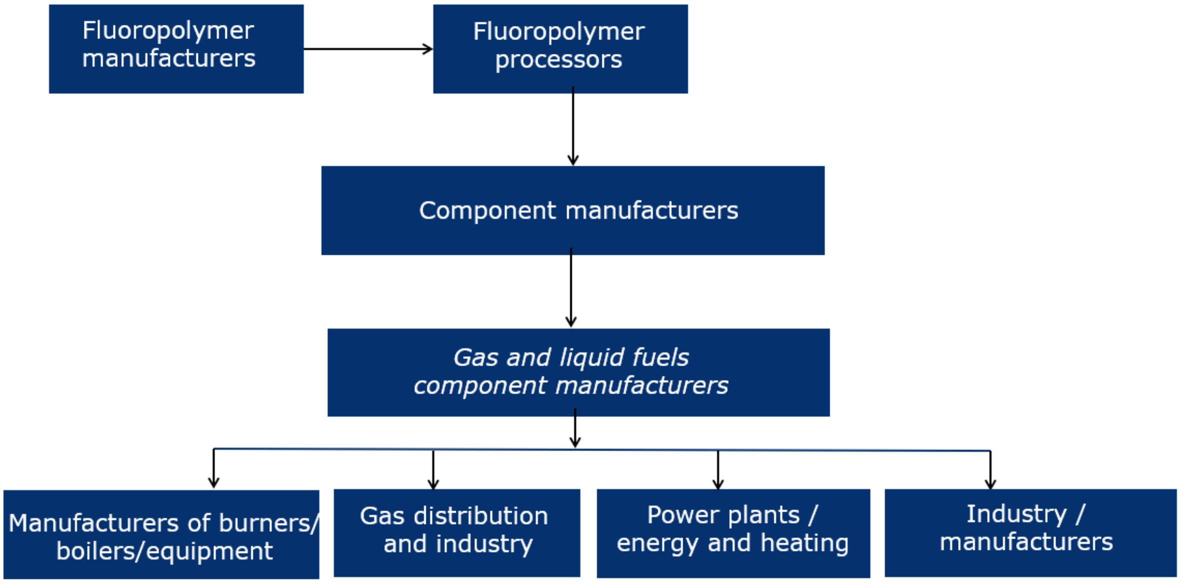

FIGURE 6: SCHEMATIC PROVIDING A SUMMARY OVERVIEW OF THE MAIN STAKEHOLDERS IN THE VALUE CHAIN OF FLUOROPOLYMER-BASED COMPONENTS IN GLF APPLICATIONS.

A non-exhaustive overview of the main customers of gas and liquid fuels end products or applications using fluoropolymer-based components is listed below:

1. Heating and Cooling Equipment Manufacturers:
   - Gas blower burner and gas boiler manufacturers (residential, commercial, and industrial environments)
   - Industrial thermal processing equipment manufacturers
   - Gas engine manufacturers for combined heat and power plants and other stationary or mobile applications, e.g., decentralized energy supply, such as biogas plants
   - Manufacturers of H_2-Ready Gas Appliances
   - Manufacturers of gas- and electricity driven air heat pumps because of PTFE in controls and bearings.

2. Gas Distribution and Supply:
   - Natural gas distribution system, transmission, and long-distance gas network operators
   - Regional gas and energy suppliers with household and industrial customers
3. Heating Applications and Metering:
   - Heating applications and further products of gas use: Climate market, process heat, intermediaries
   - Gas meters: Gas suppliers and gas meter intermediaries
4. Industrial Production and Construction:
   - Producers: Chemical and pharmaceutical industry
   - Plant construction
   - Pellet manufacturers
5. Maritime and Other Applications:
   - Maritime applications e.g., gas motors instead of heavy oil versions
   - Local Heating Transfer Stations
6. Downstream Users and Public Infrastructure:
   - Gas end users: Private households, hotels, and others
   - Public infrastructure, e.g., hospitals, public administration, landfills
   - Further industrial companies, food industry, drying applications, glass manufacturers, clinker manufacturers, laboratories, etc.

Other downstream users in the supply chain include those mentioned above as customers and any additional relevant industries.

The distributions and sales channels used are:

- Direct approach to the customer (e.g., B2B / key customers / OEM / via the Group's sales companies)
- Distribution companies
- Sales via intermediaries (sales partners, sales representatives/agents; national and international)
- Channel partners
- Solution partners
- Supply to specialist dealers and industrial representatives

Given the vast variety of stakeholders covered in this segment, it has remained difficult to ascertain the total number of stakeholders at any given supply chain level for this cluster.

2.1.1.2. Market and financial considerations

Gaseous fuels currently represent approximately a quarter of the total EU energy consumption. Approximately 26 % of this gas is utilized for power generation, including combined heat and power plants. Close to 23 % serves the industrial sector, while the majority of the remaining gas consumption is attributed to residential and services sectors, primarily for heating buildings (European Commission, n.d. d). As per the scenarios considered in the Climate Target Plan Impact Assessment, the share of gaseous fuels in total EU energy consumption is projected to be around 20 % by 2050. Consequently, gaseous fuels will continue to be a vital component of the energy mix in the coming decades, necessitating the decarbonization of the gas sector through the establishment of competitive, decarbonized gas markets (EUR-Lex, 2021b).

Proportional to the split in applications for this cluster as explained above, a distribution of the market value between stakeholders has remained difficult. Section 2.1.1.1 provides an overview of the type of stakeholders and the GLF applications of end products that encompass the variety of PFAS components covered under the scope of this derogation request. Given the diversity of stakeholders captured by this sector, financial estimates of only industry stakeholders were reasonably estimated with emphasis on figawa members. Overall, it is already evident that there are additional manufacturers of GLF components depending on fluoropolymer-based components in the EEA which could not be represented in the current report due to a lack of appropriate data.

As such, figawa members constituting more than 275 member companies generated around 34 billion Euros of revenues in 2022. The members covered under the scope of this assessment have reported that, of their individual total revenues, on an average, in 2022 a share of annual revenues of 87 % (ranging between 30 – 100 %) was dedicated to supply of GLF end products dependent on the components associated with FPs. Similarly, the share of total annual EBITs that are attributed to PFAS were estimated at 73 % on average (ranging between 38 – 100 %) in 2022.

Figure 7 depicts the annual sales revenues registered in the EEA by the figawa members for all products and for products dependent on PFAS respectively. The data shown relates to the financial years 2020, 2021 and 2022.

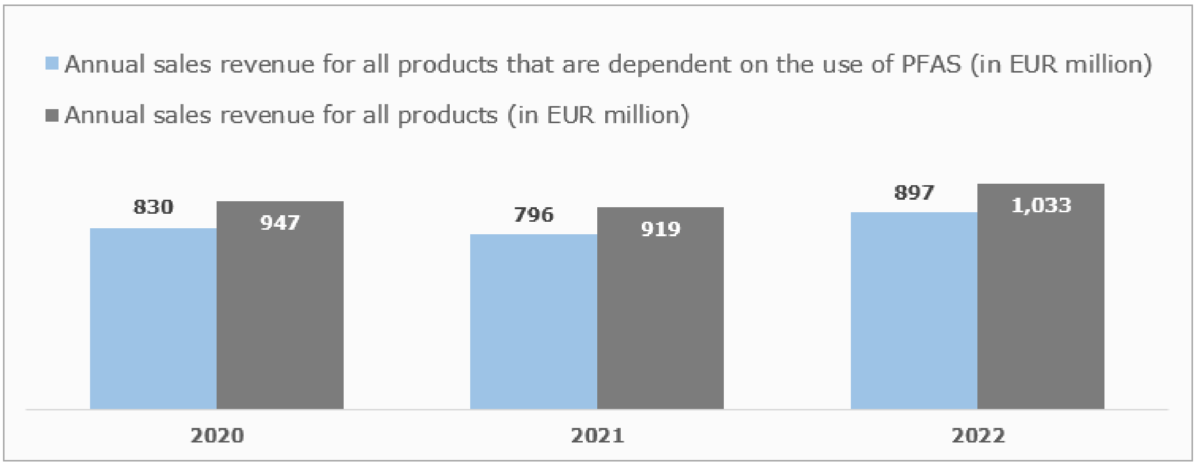

FIGURE 7: TOTAL REVENUES AND PFAS-DEPENDENT REVENUES OF WATER TREATMENT TECHNOLOGIES GENERATED BY FIGAWA MEMBERS.

Figure 8 depicts the annual earnings before interest and tax (EBIT) registered in the EEA by the Figawa members for all products and for products dependent on PFAS respectively. The data shown relates to the financial years 2020, 2021 and 2022. It shall be emphasised that the overall EBIT is an underestimation in comparison to the level of annual sales revenue because the two figawa members with the largest sales revenues could not give an estimation of their total and PFAS-dependent EBITs.

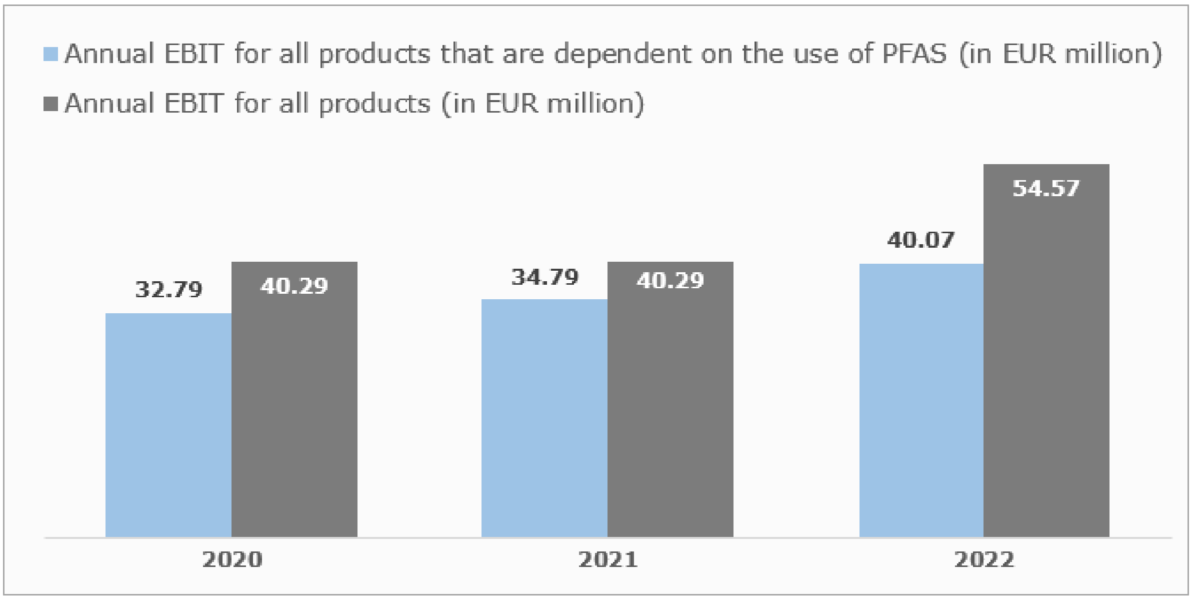

FIGURE 8: TOTAL EBIT AND PFAS-DEPENDENT EBIT GENERATED IN THE EEA BY WATER TREATMENT TECHNOLOGIES OF FIGAWA MEMBERS.

For gas and liquid fuels components, in 2022, 2,847 jobs were registered, attributed to figawa member companies employed in the EEA that are dependent on PFAS, i.e. their jobs rely on the production/sales of water distribution systems using fluoropolymer-based components.

Based on information sourced from Statistisches Bundesamt (Destatis, 2023), as of 2020, 62,531 companies have been actively involved in energy supply within the European Union. This figure correlates with a combined production value of 578 billion euros and employment of 281,487 full-time equivalents (FTEs). Deducing in 2020, by calculating the production value of energy supply per FTE, it is determined that each FTE contributed 2.05 million Euros. Data extracted from Eurostat estimates the production value of meters for gas supply or production (including calibration meters) at 540 million Euros in 2020 (Eurostat, 2023). By assuming the same ratio of production value per FTE for meters, it is estimated that this sub-sector employed approximately 263 FTEs. Other pipe components for which production values are available can often be used both for water and for gas and liquid fuels distribution (as reported by figawa members); therefore, an attribution of production and FTEs to the GLF sector is not possible. These 263 FTEs can however be assumed to be part of the 2,847 jobs (collected via survey) at the OEMs of GLF end products.

2.1.2. Description of the function(s) of Fluoropolymers and performance requirements of associated products

FPs are high-performance materials with unique properties that are needed for long-term applications. There is no single key function of FPs for the use in GLF, but a combination of several properties that are necessary to ensure the safe functioning of the system. Any alternative must be able to provide these functions simultaneously; otherwise, the safety of GLF systems will be compromised.

The fluoropolymer-based components in scope of this submission are long-lasting and inert materials that provide the following critical properties:

- FPs show very high leak-tightness and ensure that the risk of gas leakage is significantly minimised
- The chemical resistance of FPs protects parts and equipment from chemical aging and material deterioration
- FPs show excellent resistance to a wide range of temperatures and pressures
- FPs have a very low friction coefficient providing excellent reduction of friction for gliding elements

These properties and further critical properties are described in detail in the next passages.

Leak tightness

FPs are used in O-rings, sealing gaskets, diaphragms, valves, sensors and other components, which require a high level of leak tightness to avoid any potential leakage of highly flammable and combustible gases and liquids. As this is a non-negotiable safety-critical key feature, the leak tightness is defined is various European standards, such as

- EN13611:2019 Safety and control devices for burners and appliances burning gaseous and/or liquid fuels – General requirements
- EN 161:2022 Automatic shut-off valves for gas burners and gas appliances
- EN 88-1:2022 Safety and control devices for gas burners and gas burning appliances - Part 1: Pressure regulators for inlet pressures up to and including 50 kPa
- EN 88-2:2022 Safety and control devices for gas burners and gas burning appliances - Part 2: Pressure regulators for inlet pressures above 50 kPa up to and including 500 kPa
- EN 88-3:2022 Safety and control devices for gas burners and gas burning appliances - Part 3: Pressure and/or flow rate regulators for inlet pressures up to and including 500 kPa, electronic types
- EN 126:2012 Multifunctional controls for gas burning appliances
- EN 1854:2022 Safety and control devices for burners and appliances burning gaseous and/or liquid fuels - Pressure sensing devices for gas burners and gas burning appliances
- EN 298:2022 Automatic burner control systems for burners and appliances burning gaseous or liquid fuels
- EN 125:2022 Flame supervision devices for gas burning appliances - Thermoelectric flame supervision devices
- EN 549:2019+A1:2023 Rubber materials for seals and diaphragms for gas appliances and gas equipment
- EN 1643:2022 Safety and control devices for burners and appliances burning gaseous and/or liquid fuels - Valve proving systems for automatic shut-off valves
- EN 1359:2017 Gas meters - Diaphragm gas meters
- ISO 17089-1:2019 Measurement of fluid flow in closed conduits - Ultrasonic meters for gas - Part 1: Meters for custody transfer and allocation measurement
- OIML R 137-1 & 2: Part 1: Metrological and technical requirements, Part 2: Metrological controls and performance tests
- EN 12480:2018 Gas meters - Rotary displacement gas meters

- EN 12261:2018 Gas meters - Turbine gas meters
- EN IEC 60079-0:2018 Explosive atmospheres - Part 0: Equipment - General requirements
- IEC 60079–1 to -47: Requirement details in these 47 Standards regarding the electrical ignition protection type
- EN ISO 80079 –20 to - 49: 29 Standards for the mechanical ignition protection

Chemical resistance / inertness

FPs show excellent chemical resistance towards several chemical groups, such as strong acids, strong bases, strong oxidants, salts, halogens, and solvents (chlorinated solvents, aliphatic- & aromatic). In GLF applications components are exposed to various substances, such as aliphatic hydrocarbons, ammonia, hydrogen and hydrogen sulphide. Typical applications are climate neutral biogas applications with high H_2S concentrations.

The chemical resistance properties of FPs protect the installations from chemical degradation and chemical aging and thereby ensure that the safety features perform as intended, for a minimum of 10 years and for wide temperature- and pressure ranges.

Various standards define the minimum requirements for chemical resistance in GLF applications. Rubber materials used in gas installations, for example, must fulfil the requirements regarding chemical resistance as specified in EN 549:2019+A1:2023.

Pressure resistance

As described above, GLF transport and storage systems operate under elevated pressures, which can reach up to 250 bar. Pressure resistance ensures that the material properties of FPs do not change under these conditions and that safety-critical features are provided as intended, for a minimum service lifetime of 10 years.

The requirements of pressure resistance are specified for individual components in European standards, such as in the EN 88 series for pressure regulators in gas appliances.

Temperature resistance

GLF components/systems are exposed to a temperature range of -40 °C up to 120 °C. This wide range is on the one hand due to the outside temperature, which changes based on seasons and mode of transport / storage (underground / subsea pipelines; inside / outside storage; etc.). On the other hand, certain electrical and electromagnetic components can reach 120 °C or more due to electrical current. In addition, GLF equipment must also show resistance towards quick and sudden temperature changes.

FPs must be able to retain their properties in the specified temperature range. Otherwise, a leakage of gas might occur with the risk of explosion. The requirements of temperature resistance are specified for individual components in European standards, such as:

- EN 549:2019+A1:2023 for rubber materials used in gas installations
- EN 682:2002 + A1:2005 for material requirements for seals used in pipes and fittings carrying gas and hydrocarbon fluids
- EN 13611:2019 for safety and control devices for burners and appliances burning gaseous and/or liquid fuels

Material properties

FPs combine properties, such as flexibility, durability, high tensile strength and impact resistance. This allows them to maintain their physical properties under a wide range of harsh conditions.

Various standards define requirements for materials in use, such as:

- EN 549:2019+A1:2023 for rubber materials used in gas installations
- EN 334:2019 for gas pressure regulators
- EN 682:2002+A1:2005 for elastomeric seals (materials requirements for seals used in pipes and fittings carrying gas and hydrocarbon fluids)
- EN 14382:2019 for gas safety shut-off devices

Anti-friction / gliding properties

FPs have one of the lowest coefficients of friction providing them with excellent low-friction and gliding properties. Their gliding protects surfaces and components from friction and thus the risk of wear-tear, which leads to decreased efficiency and product durability. This is being used in lubricant applications for GLF components, such as valves with sliding elements, bearings for anchors, shafts and axes. Gliding properties are an inherent condition for leak tightness. In addition, low friction extends lifetime and effectively saves energy, as less energy is needed to move lubricated parts.

Abrasion resistance of rubber articles is for example tested according to ISO 4649:2017.

Flame-retardant properties

FPs have inherently flame-retardant properties, resulting in low flammability and no flame propagation. This makes them especially suitable for applications with combustible and highly flammable substances, such as GLF applications. FPs act as an additional safety barrier in case that sparks, or other ignition sources could lead to fire and explosion. Their low flammability inhibits the generation and spreading of fire from ignition sources.

2.2. Efforts made to identify alternatives

2.2.1. Research and development

As depicted in Figure 6, companies providing equipment and technologies for GLF systems are located at the bottom half of the value chain. The figawa members of the GLF sector (‘Gas & Liquid Fuels technology manufacturers’) do not produce the individual components of GLF systems (e.g. sealing rings, gaskets, membranes), but assemble the required components, which they purchase from a broad range of suppliers (‘component manufacturers’), into the various GLF systems. Consequently, any research and development (R&D) on alternative substances and technologies must be coordinated and conducted with the component manufacturers and producers of (alternative) high-performance materials (‘chemical suppliers’).

The members of figawa, DGMT and AE are in communication with their suppliers regarding:

- Availability of alternative materials / components
- Testing of alternative materials / components lab-scale
- Testing of alternative materials / components during application

- Certification requirements

However, it must be highlighted that the majority of suppliers do not provide any alternative materials and technologies and it must be assumed that most producers of materials and component manufacturers are still at the early stages of R&D, if this has been started at all.

In summary, no suitable alternatives are available at this stage, as the high requirements for GLF systems, as requested by several regulations and standards, aggravates the search for suitable alternative materials / technologies.

2.2.2. Identification of alternatives

As stated in the previous section, R&D efforts for the identification of alternatives are still at a very early stage. The table below provides an overview on potential alternatives that have been either mentioned by suppliers or have been taken from literature. However, available data is limited, as FPs are not classified and are considered PLCs, thus there has been no need in industry to assess alternatives. Therefore, the figawa members of this cluster aim to further identify alternatives and conduct tests for those that will be shortlisted based on availability, economic feasibility, safety considerations and an initial screening of technical feasibility. This will take time, as depicted in section 3.

As can be seen from the table below, it is not possible to identify one alternative that might be suitable for every product and component therein. Hence, R&D efforts will take significant time to identify suitable alternatives for all components, which are needed for an efficient and safe GLF applications. This is also reflected in section 3, where a hypothetical substitution timeline is discussed.

Several materials have been studied in literature for GLF sealing applications. One substance studied is ethylene propylene diene monomer rubber (EPDM). O rings made from EPDM showed cracks when exposed to elevated pressures. In one study (Koga, et al., 2013), EPDM was tested for gas permeability with hydrogen, helium and nitrogen as test gases at 10 MPa and 25 °C. After decompression the O rings were investigated. For all test gases EPDM showed blisters with the blister size increasing in the following order: $N_2 < H_2 < He$. Another study tested the effects of hydrogen pressure, ambient temperature and pressure cycle pattern on fracture behaviour of O-rings made from EPDM (Yamabe, et al., 2013). At the lowest tested pressure of 10 MPa, blisters were observed after decompression. Hence, EPDM is not suitable to be used as sealing materials in GLF applications, as pressure resistance is not given.

Silicone rubbers were tested for their sealing properties, albeit for applications in fuel cells (Wu, et al., 2018) (Cui, et al., 2011) (Chang, et al., 2016). Nonetheless, the results are relevant, as all studies have shown that the temperature resistance of silicone rubbers is insufficient. At elevated temperatures, silicone rubbers start to age and lose their favourable material properties.

Another material studied for fuel cell applications is glass ceramics. Glass ceramics show promising features, such as excellent temperature and pressure resistance. However, regarding their leak-tightness, there are several differing statements. In one study, glass fibre reinforced glass-ceramic was tested as sealing material in fuel cells. It was shown that gas-tight sealing can be achieved at elevated pressures for all tested temperature ranges with the exception of room temperature (Timurkutluk, et al., 2019). In another study, gas leakage was observed when using ceramic fibre reinforced glass ceramic sealants for fuel cells (Timurkutluk, et al., 2022). The results of studies depend on the type of ceramic material used, as well as on the type of reinforcement/treatment of the sealant. However, according to EN 549 and EN 682, only elastomers are allowed for usage as sealant in components (e.g. in valves).

TABLE 3: OVERVIEW OF POTENTIAL ALTERNATIVES

Potential alternative	Potential application	Availability	Technical feasibility	Further considerations
Ethylene propylene diene monomer rubber (EPDM)	Sealing materials	Available	Insufficient pressure resistance No certification due to EN 549 possible	Risk of leakage → safety concern
Glass ceramics	Sealing materials	Available	Application in GLF requires more R&D to conclude technical feasibility	According to EN 549 and EN 682, only elastomers are allowed for usage as sealant in components (e.g. in valves)
Nitrile butadiene rubber (NBR)	O-Rings Gaskets Sealing material Bearings	Available	Insufficient chemical resistance Decreased temperature resistance Increased friction leads to higher demand for movement (0.5 % loss of energy)	Increased CO_2 footprint due to higher energy demand.
Liquid Silicone Robber (LSR)	Membrane (gas valve) Gaskets O-Rings	Available	Decreased leak tightness (H_2 permeability) Decreased chemical resistance Limited control properties	Risk of leakage → safety concern
Poly(meta-phenyleneisophthalamide)	Bearing	Available	High modulation demand of efficient heating systems	Increased failure rates → safety concern

(Nomex©)			needs operation at low speeds Insufficient gliding properties → leads to stopping of engine	
Poly(oxy-1,4-phenyleneoxy-1,4-phenylenecarbonyl-1,4-phenylene) (PEEK)	Sealing materials	Available	Sufficient chemical- and temperature resistance Insufficient gliding properties and dielectric strength for certain applications Insufficient flame-retardant properties	Economically not feasible According to EN 549 and EN 682, only elastomers are allowed for usage as sealant in components
Polyphenylene sulfide (PPS)	Gas valves	Available	Decreased gliding properties Decreased chemical resistance Decreased temperature change resistance Limited control properties	According to EN 549 and EN 682, only elastomers are allowed for usage as sealant in components (e.g. in valves)
Polyurea	Gas valve (coating / lubricant)	Available	Decreased leak-tightness Decreased gliding properties Decreased chemical resistance Decreased temperature	Risk of leakage → safety concern

			change resistance	
Polyurethane (PU)	Sealing materials	Available	Decreased chemical resistance Insufficient pressure resistance (results in blockage of components (e.g. valves))	According to EN 549 and EN 682, only elastomers are allowed for usage as sealant in components (e.g. in valves)
Silicones	Sealing materials	Available	Insufficient temperature resistance High H_2 permeability	Risk of leakage → safety concern

3. SUBSTITUTION TIMELINE

figawa primarily supports an exemption of fluoropolymers by way of a time-unlimited derogation for the applications relevant for its members (see section 2.1) or at least the longest derogation period to perform the research necessary to find and implement alternatives that meet our high standards, which would certainly require a minimum of 22 years.

In this section a hypothetical substitution is described, as there are currently no suitable alternatives available, and it is unclear if substitution will ever be possible for all GLF components. Nonetheless, the timeline needed for a potential substitution has been estimated. However, it must be highlighted that this is based on assumptions and estimations and serves as a justification why a derogation period is requested, which goes beyond the longest provided period of 12 years in the PFAS restriction proposal[5].

In addition, the estimated substitution timeline generalises all applications for gases and liquid fuels. In reality, all individual components must be assessed separately or at least in product category groups, as requirements and testing schemes might differ. In some cases, a substitution may be successful, but in other cases, especially for components with direct contact to gases and liquid fuels under high temperature and pressure, substitution is expected to fail.

Figure 9 and Table 4 describe the substitution timeline and the steps included therein. A total substitution timeline of 22 years is estimated if provision of spare parts is not included. If we include spare parts, the substitution timeline extends to 28-42 years. It must be highlighted that for certain applications, provision of spare parts is required by standards. For example, according to EN 15459-1:2017 (energy performance of buildings), replacements of controls (e.g. gas valves, automatic stoker) in heaters must be carried out using the equivalent component that was used for the type examination. This standard further specifies that spare parts must be available for 20 years.

As described in section 2.1.1.1, the GLF system manufacturers are dependent on R&D and substitution efforts from component manufacturers and chemical suppliers. According to our information based on communication with our immediate suppliers, R&D for alternatives is still at a very early stage and some have not yet started the search for alternatives. Hence, in the substitution timeline the time needed for suppliers to identify and develop alternative materials and technologies is included as Phase I. We have estimated a best case where the supply chain will require seven years to provide multiple alternatives for different components in GLF applications. This timeline can be shorter for some applications / components and in other cases require more than seven years.

Once a palette of alternative components becomes available, figawa members can then start their own R&D process and test the provided parts in-house for GLF applications (Phase II). In the case that alternatives prove to be successful, the next Phase (Phase III) entails product re-designs to adjust for the new components. The adjusted products are then subject to further testing at customer sites to ensure that the components are suitable for actual use conditions and for longer periods. If the alternative products fulfil the customers' requirements, global regulatory and technical requirements, as well as adjustment of production lines must then be addressed in Phase IV. This could mean that

[5] For the socio-economic impact assessment, a time-unlimited derogation period has been used for the calculations

certain technical standards and/or customer requirements might need to be changed and adjusted or in other cases, certain products are subject to global re-certification. This process can be costly and time-consuming. Upon successful re-certification and regulatory approvals, products containing alternative components can then be gradually included into the product portfolio and introduced to the market (Phase V). To allow customers to gradually change to the new products, a transition phase (Phase VI) is necessary to complete substitution.

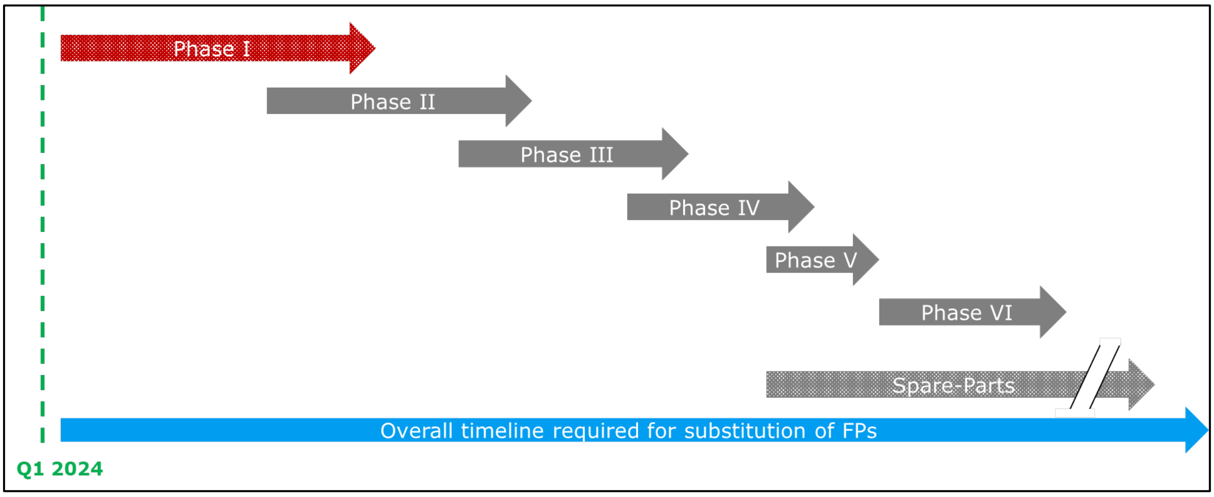

FIGURE 9: OVERVIEW OF SUBSTITUTION PHASES

TABLE 4: DESCRIPTION OF SUBSTITUTION PHASES

Phase	Description	Period (in years)
I	R&D of suppliers: Identification, testing and commercialisation of alternative materials and technologies by chemical suppliers and component manufacturers	7
II	R&D of potential alternatives (in-house / with suppliers) Testing / R&D of potential alternatives (in-house / with suppliers)	5 (2 years overlap with Phase I)
III	Product re-design and readjustments External R&D and testing of potential alternatives (at customers) Large-scale tests	4 (1 year overlap with Phase II)
IV	Global product registration, (re-)certification, customer qualification, e.g. EU type-examination certificate Changes to existing production lines and/or setting up new production lines, product descriptions / manuals	4 (1 year overlap with Phase III)
V	Inclusion of alternative products into market / addition to product portfolio	3 (1 year overlap with Phase IV)
VI	Transition phase to 100 % substitution	4
Spare-parts	Availability of FP-containing spare parts	10-20 (starting from

		Phase V)
Total substitution timeline without spare-parts (in years)		**22**
Total substitution timeline with spare-parts (in years)		**28-42**

4. SOCIO-ECONOMIC ANALYSIS

This chapter aims to compare the environmental risks associated with continued use of fluoropolymers with the corresponding socio-economic benefits to the EEA society. The consequent chapters draw upon the analysis of the chemical safety report and input provided by figawa members.

4.1. Emissions as a proxy for risk

figawa members utilize FPs for the safe and durable operation of their products, including GLF components. These members primarily engage in assembling end products, and emissions from the manufacturing phase are considered controlled and negligible. During the intended use of end products, emissions are also considered controlled due to the chemical stability and durability of FPs. Potential emissions may arise from wear-and-tear or the use of lubricants, although these are estimated to be small.

Data regarding emissions from waste treatment, such as incineration, are limited, but it is expected that more information will become available in the future. This may lead to improvements in abatement technologies. Both figawa and its members support the need for more data to establish appropriate regulatory approaches. Manufacturers of FPs are already taking steps to reduce emissions, such as phasing out the use of fluorosurfactants in production (Solvay, 2023) and the development of non-fluorinated polymerization aids (Gujarat Fluorochemicals, 2022).

In conclusion, figawa members produce essential products for GLF applications with a low concentration of FPs. The exposure potential during manufacturing, use, and disposal is minimal, although some emissions may occur.

4.2. Restriction scenario

According to current expectations, a potential PFAS restriction is assumed to enter into force mid-2025, with the ban being enforced in 2027. In this sense, two restriction options (ROs) have been proposed (ECHA, 2023):

- RO1: A full ban with no derogations and a transition period of 18 months
- RO2: A full ban with use-specific time-limited derogations (18 month-transition period plus either a 5- or a 12-year derogation period)

Notably, as stated in the previously published restriction proposal, RO2 is considered to be the preferred option by the submitting Member States (ECHA, 2023).

As previously mentioned in section 2.2, no substances of concern (*i.e.*, short-chain and volatile PFAS substances) are used for the manufacturing of fluoropolymer-based components for use in GLF applications within the scope of the current report. As of now, there are no known substitute materials that meet the required properties and market demands, especially concerning safety-related properties and compliance with European directives (GAR and PED) and standards as the current PFAS components used in GLF applications. The use of PFAS (Per- and polyfluoroalkyl substances) is therefore considered indispensable for the operation of these components.

Given the classification of fluoropolymers as polymers of low concern (PLC) (Korzeniowski, et al., 2023) and the absence of PFAS-free alternatives to GLF applications using fluoropolymer-containing components, figawa members commissioning the current report request a time-unlimited derogation for the use of fluoropolymers in gas and liquid fuels components.

To assess the socio-economic impacts on the EEA society that would result in a restriction scenario in which no such time-unlimited derogation would be granted, the following sections introduce the business reactions of the different actors in the value chain (see section 2.1.1.1) and the associated consequences that would become applicable in such a scenario.

4.2.1. Business reactions of upstream stakeholders in the value chain

In a hypothetical scenario where fluoropolymers are not exempted from PFAS restrictions, significant consequences would be observed for fluoropolymer producers, processors, and manufacturers of components. The supply chain would be disrupted, as fluoropolymer producers and processors could no longer provide their products to component manufacturers. This disruption may lead to a complete closure of associated business activities for the component manufacturers.

The severity of the disruption could potentially result in some companies facing a complete shutdown of their operations within the EEA, especially if their non-fluoropolymer-dependent production activities are unable to sustain long-term business viability.

As a result, there would be foregone profits and job losses for fluoropolymer producers, processors, and component manufacturers. In cases where a complete shutdown becomes necessary, additional one-off investment costs for dismantling facilities may also be incurred.

4.2.2. Business reactions of OEMs of GLF end products

In a stringent context, all OEMs operating within the EEA and subject to this assessment would be obligated to completely discontinue their related business lines. This requirement could result in some companies having to shut down their operations entirely, especially if their product range heavily relies on fluoropolymer based GLF applications. Depending on individual circumstances, such as their presence in non-EEA markets or the existence of facilities outside the EEA or other significant business areas, some manufacturers might consider relocating entirely to non-EEA countries or transitioning to entirely new business domains. This would entail its own set of challenges accompanied with modifying or completely redesigning their assembly lines.

For certain OEMs, a considerable portion of their product portfolio would be affected, and finding suitable replacements for these components would be challenging due to their unique properties. Some OEMs mention that in the past, efforts have been made to reduce the use of PFAS, but these attempts have not been entirely successful. As a consequence of the restriction, developing and registering new components would be necessary, adding to the complexity of the situation. Furthermore, for some, the success of the current product portfolio is closely linked to the existing set of components, making the transition even more demanding.

In response to the imposed restrictions, some production may be relocated to countries outside the EU. However, this could have devastating consequences for the European gas industry, as the supply of spare parts would also be disrupted, potentially leading to an energy supply crisis. To offset the restricted market in the EEA, production capacities in other countries like the USA, China, or Taiwan would likely be expanded to cater to their respective markets.

4.3. Impact assessment

As presented in chapter 4.2, the lack of a time-unlimited derogation for the use of fluoropolymers for gas and liquid fuels components in the context of the PFAS restriction would generate consequences for several stakeholders along the specific value chain, thus further impacting the entire EEA society. In this regard, the following impacts will be covered in this chapter, either in a monetized form – whenever quantitative data was available – or in a qualitative manner:

- **Broader societal impacts**
- **Socio-economic impacts**
    - Foregone profits at the level of manufacturers of gas and liquid fuels products *(monetization available)*
    - Foregone profits at the level of manufacturers of gas and liquid fuels components *(monetization available)*
    - Further foregone profits at the level of fluoropolymer manufacturers and processors as well as component manufacturers
    - Job losses at the level of gas and liquid fuels components producers *(monetization available)*
    - Additional one-off capital costs for replacing existing production lines or components *(monetization available)*
    - Increased operating costs for affected industrial and public sites

For the current impact assessment, the PFAS restriction is assumed, for simplicity, to enter into force mid-2025. While accounting for an 18-month transition period, the impact realization period is considered to begin in 2027. The base year of the analysis is 2025 and the impact assessment period was set to a timeframe between 30 and 45 years, in agreement with the impact assessment period considered in the PFAS restriction proposal (ECHA, 2023). To monetize the respective impacts, a social discount rate of 3 % was consistently used throughout the assessment when deriving the net present value (NPV) or the annualized value for any given amount, in accordance with the latest guideline from ECHA on socio-economic analysis (ECHA, 2011).

For the applicable impact categories mentioned above, not all impacts have been monetised in the following chapters. The valuation of impacts and extrapolation thereof has remained difficult due to constraints in data availability for the entire sector and all stakeholders. Data, wherever applicable for OEMs, was obtained by some figawa members for exemplary valuation which must be seen as a bare minimum indication of socio-economic estimates at least at the OEM level in the supply chain (see Figure 6). Impacts associated with other stakeholders in the supply chain are only qualitatively explained.

4.3.1. Social impacts

With respect to the societal consequences incurred in the EEA in case of the considered impact assessment scenario, this section provides an overview over the effects related to population health as well as unemployment.

4.3.1.1. Broader societal impacts

As previously explained in section 4.2, imposing a PFAS restriction on fluoropolymer-based components in GLF applications would have significant repercussions on the security of energy supply, particularly for those reliant on gas and liquid fuels. The safety and dependability of supply would be jeopardized for sectors such as natural gas provisioning, energy (inclusive of the heat pump market), and various industries reliant on process heat and thermal operations, including steel production and the automotive sector. Additionally, industrial procedures, like drying operations in the food industry, would be adversely affected. Under these constraints, customers might face incomplete systems and facilities, leading to substantial revenue losses and weakened EBIT. Of particular concern is the potential for compromised heating solutions in critical public infrastructure, such as hospitals and nursing homes, thereby threatening their essential services. As such, heat provision within the EEA would become uncertain.

Furthermore, the PFAS restriction could also have implications for the future adoption and development of alternative energy sources, like hydrogen. The growing demand for hydrogen as an alternative fuel source highlights the importance of considering exemptions and ensuring a stable supply chain for essential fluoropolymer-based components. Components containing PFAS, such as valves and regulators, remain crucial to the safe and effective utilization of hydrogen fuel.

When closed vacuum chambers are not used, there is a higher risk of carbon monoxide production because safe gas blowers, high pressure blowers, and gas valves are not available for use. In addition, the largest gas meter and gas appliance manufacturer emphasised the potential significant shortage of gas supply and gas use products.

The imposition of PFAS restrictions on fluoropolymer-based components may engender increased worker safety risks, particularly concerning carbon monoxide generation. The absence of secure gas blowers, high-pressure blowers, and gas valves for spare parts may lead to a decrease in the usage of fully enclosed vacuum chambers, which play a crucial role in preventing carbon monoxide leakage during various manufacturing and industrial processes.

Moreover, the largest gas meter and gas appliance manufacturers have underscored the potential for significant supply shortages in gas delivery and gas utilization products as a result of the PFAS restrictions. Such shortages could adversely impact numerous industrial sectors and potentially affect residential and commercial consumers. The disruption to the supply chain, coupled with the increased risk of carbon monoxide generation, raises concerns about the safe and uninterrupted provision of gas services and the subsequent implications for public health and safety throughout the economy.

Despite these consequences being of major importance for the EEA society, these aspects are only mentioned here at a qualitative level, due to limitations concerning available data.

4.3.1.2. Social cost of unemployment

As already emphasized in sections 4.2.1. and 4.2.2., no time-unlimited derogation for the use of fluoropolymers in GLF applications from the PFAS restriction would result in job losses at OEMs of such technologies as well as the level of upstream stakeholders in the value chain. The social cost associated with these job losses that would be incurred by the EEA society in such an impact assessment scenario is monetized in this section.

Methodology

According to a valuation paper commissioned by ECHA (Dubourg, 2016), the social cost of unemployment associated with job losses can be evaluated based on the following components:

- The value of lost output/wages during the period of unemployment
- The cost of acquiring a new job
- Recruitment costs
- Scarring costs (i.e., the impact of being made unemployed on future earnings and employment possibilities)
- The value of leisure time during the period of unemployment

The latter component is defined as a negative cost (i.e., a benefit) of unemployment. As such, it is subtracted from the total cost resulting from the first four components.

For the current assessment, the figures from the aforementioned paper have been updated with recent data representative for 27 EU countries, by using 2021 estimates for wages (Rogers & Marques, 2021) and Eurostat 2021 data on the duration of unemployment (Eurostat, 2022 a.). The figures for average wages were projected to the year 2027 when they are assumed to accrue by using an average Labour Cost Index (LCI) of 2.425 % based on the LCI values registered between 2016 and 2021 and provided by Eurostat (Eurostat, 2022 b.). Notably, although estimations for wages are already available for 2022, for consistency with the data on unemployment duration, 2021 data has been used.

This approach leads to a value of the costs associated with losing one job of 98,151 Euros in 2027, which is comparable to the population-weighted average for EU-27 reported in the aforementioned valuation paper (Dubourg, 2016). By multiplying the number of job losses expected in the EEA in such an impact assessment scenario with the costs associated with losing one job, the total social costs incurred by the EEA society could be computed.

Notably, for the evaluation of the number of job losses in such a scenario, the following additional assumptions were applied:

- It is estimated that 4,239 jobs dependent on the production/sales of gas and liquid fuels components relying on fluoropolymers would be lost at manufacturers of such technologies, which is higher than the directly PFAS-related jobs in total (2,847) (see baseline employment information in section 2.1.1.2). This is due to the circumstance that some companies would take into consideration a total closure of the site in the EEA because due to the restriction even the non-PFAS related business cannot be maintained in a profitable manner. It can be assumed that the 263 employees involved in the production of meters for gas supply or production, including calibration meters, as estimated in section 2.1.1.2, are at least partly included in these jobs lost.

Results

At the level of OEMs of GLF end products relying on fluoropolymer based components, it is estimated that about 4,239 jobs would be lost in the EEA in an impact assessment scenario. This number of jobs lost would consequently raise **392.18 million Euros** in terms of social costs for the EEA society (NPV 2025). The value is equivalent to an annualized amount of **20.01 million Euros** per year of additional social costs considering a 30-year impact assessment period. This translates to an annualized amount of **16.00 million Euros** over a 45-year period (Table 5).

TABLE 5: THE SOCIAL COST OF UNEMPLOYMENT INCURRED BY THE EEA SOCIETY IN CASE OF THE IMPACT ASSESSMENT SCENARIO DUE TO JOB LOSSES AT OEMS OF GLF END PRODUCTS

Socio-economic impact factor	Value [million Euros]
The social cost associated with all job losses at manufacturers of gas and liquid fuels components in 2027	416.06
Net present value in the base year (NPV 2025)	392.18
Annualized amount over a period of 30 years	20.01
Annualized amount over a period of 45 years	16.00

An impact assessment scenario is expected to result in further job losses in the EEA at the level of upstream stakeholders in the value chain (e.g., fluoropolymer producers, processors, and manufacturers of input components). These job losses would result in additional social costs for the EEA society, which would result in an equivalent annualized amount in terms of costs for the EEA society per year over a 30-year or 45-year impact assessment period.

4.3.1. Economic impacts

As outlined in the beginning of chapter 4.3, the absence of a time-unlimited derogation for the use of fluoropolymers in gas and liquid fuels components in the context of the PFAS restriction would generate several economic impacts for the different stakeholders in the value chain described in section 2.1.1. This section will cover the following impact categories incurred in the EEA:

- Producer surplus losses
- Additional one-off investment costs
- Additional operating costs

4.3.1.1. Producer surplus losses

As already explained in chapter 4.2, in a restriction, all stakeholders whose businesses depend on these substances would be affected.

Although fluoropolymer producers and processors would experience substantial foregone profits in such a restriction scenario (see section 4.2.1), for the current impact assessment these effects remain unquantified due to a lack of appropriate data. Given the current data availability, to maintain a conservative approach, the focus of this chapter is limited to the monetization of the foregone profits incurred by OEMs of GLF end products.

Methodology

According to a guideline published by ECHA on evaluating losses in producer surplus, these foregone profits are the result of premature retirement of productive capital assets and represent losses to the EEA society (ECHA, 2021a). Based on this methodology, the foregone profits can be accounted for as producer surplus losses for the remaining service lifetime of capital assets at the point of decision making. The remaining service lifetime is based on the period of time needed by competitors to take over the respective market share dependent on the substance use (ECHA, 2021a).

Consequently, the following assumptions were made to monetize these producer surplus losses within the EEA due to foregone profits:

- To maintain a conservative approach and in line with the above-mentioned guideline (ECHA, 2021a), foregone profits were considered to accrue over a period of 2 years only.
- The valuation of producer surplus losses uses EBIT as a proxy. EBIT losses have been considered to start occurring in 2027.
- The member companies in total estimated that nearly all EBIT dependent on the sales of gas and liquid fuels components relying on fluoropolymers would also be lost by the respective manufacturers (see baseline financial information in section 2.1.1.2).
- The EBIT values of the year 2022 EBIT were considered a conservative proxy for the EBIT values expected to be registered in 2027, i.e. potential growth rates between 2022 and 2027 have not been taken into account.

Results

No time-unlimited derogation for the use of fluoropolymer-based components in GLF end products would lead to foregone profits of 73.91 million Euros (NPV 2025) for the EEA society. Notably, this amount only accounts for the producer surplus losses incurred in such an impact assessment at the level of the gas and liquid fuels components. Annualized over a 30-year impact assessment period, this amount is equivalent to 3.77 million Euros in terms of losses for the EEA society per year. Considering a 45-year period, the annualized costs become equal to 3.01 million Euros per year (Table 6).

TABLE 6: FOREGONE PROFITS AT OEMS OF GLF END PRODUCTS RELYING ON THE USE OF FLUOROPOLYMER BASED COMPONEN IN CASE OF THE IMPACT ASSESSMENT SCENARIO.

Socio-economic impact factor	Value [million Euros]
Foregone profits per year at manufacturers of gas and liquid fuels components in the years 2027 and 2028	39.78

Net present value in the base year (NPV 2025)	73.91
Annualized amount over a period of 30 years	3.77
Annualized amount over a period of 45 years	3.01

It has to be noted that this is an underestimation of the lost profits on the real sector within the EEA, since these data only refer to companies with their legal entity based in Germany. In some cases, piping components are designed and used both for water and for gas pipes, where the exact share of revenues and EBITs attributed to water and the gas and liquid fuels sector remained difficult to estimate.

4.3.1.2. Additional one-off investment costs

In section 4.2.2 it has been already outlined that, in the absence of a time-unlimited derogation from the PFAS restriction for the use of fluoropolymer based components in gas and liquid fuel installations, such existing installations at all plants, industrial, public and private sites would have to be replaced. The additional capital costs arising as a result of such technology replacements are estimated in the current section.

Methodology

As already explained in detail in section 4.2.2., OEMs subject to this assessment would potentially be obligated to completely discontinue their related business lines with fluoropolymer-based gas and liquid fuels applications. Thus, some manufacturers might consider relocating entirely to non-EEA countries or transitioning to entirely new business domains. Therefore, the imposed restrictions could have enormous consequences for the European gas industry, which cannot be quantified to all extent.

In the following, the total one-off investment costs are based on estimations of the figawa member companies for their own companies only. They estimated e.g. costs for decommissioning and scrapping of all machines and systems, development costs for testing new materials and replacement of PFAS or in a worst case for a total relocation of production outside of the EEA in the year 2027. Some member companies also mentioned that the investment costs would all or partly be borne by their suppliers.

Results

Overall, a lack of a time-unlimited derogation from the PFAS restriction for the use of fluoropolymer-based components in GLF end products would result in additional capital costs for the figawa member companies of **49.01 million Euros** (NPV 2025). This is equivalent to an annualized amount of **2.50 million Euros** in terms of additional costs for the EEA society per year over a 30-year impact assessment period. Over a 45-year period, the amount is equivalent to **2.00 million Euros** per year (Table 7).

TABLE 7: ADDITIONAL CAPITAL COSTS FOR DECOMMISSIONING/REPLACING EXISTING GAS AND LIQUID FUELS INSTALLATIONS AND TECHNOLOGIES IN THE EEA IN CASE OF THE IMPACT ASSESSMENT SCENARIO.

Socio-economic impact factor	**Value [million Euros]**
Additional one-off capital costs for in the EEA in 2027	52.00

Net present value in the base year (NPV 2025)	49.01
Annualized amount over a period of 30 years	2.50
Annualized amount over a period of 45 years	2.00

4.3.1.3. Additional operational costs

As already described in section 4.2.2, in case no time-unlimited derogation from the PFAS restriction would be granted for the use of fluoropolymer based components in GLF end products, all industrial processes reliant on gas and/or liquid fuels are expected to suffer from delays, increased maintenance costs, and potential disruptions in gas and liquid fuels distribution systems. Due to lack of appropriate data for a quantitative assessment, these impacts are however only qualitatively described at this stage and are not accounted for the monetization of impacts in this report.

4.3.2. Distributional impacts

In section 4.3.1.2, it was already mentioned that a PFAS restriction covering gas and liquid fuels components using fluoropolymer-based components would result in several jobs to be lost in the EEA throughout the value chain of such technologies. As a result of such job losses, significant severance payments would be incurred by EEA companies where dismissals would become necessary. Nevertheless, such payments are considered distributional impacts and are not counted towards the overall monetized costs projected in this impact assessment.

It should be noted that the socio-economic impacts discussed in the current report would tend to be distributed throughout the EEA, with several countries being impacted to different extents. In particular, the countries and industrial regions in which manufacturers of gas and liquid fuels components are based (e.g., Germany, Italy, Finland, Slovakia) would be most affected from the perspective of producer surplus and job losses. Meanwhile, increasing gas and energy in general may affect especially Member States in the Northern parts of Europe more than the others, and in particular those countries and regions mostly using and having available natural gas as an energy source.

4.3.3. Compilation of socio-economic impacts

Table 8 provides a summary overview of the socio-economic impacts that would be incurred in the EEA in case there would be no time-unlimited derogation from the PFAS restriction for the use of fluoropolymer-based components in GLF end products. Overall, the corresponding monetized costs sum up to a total of **515.10 million Euros** (NPV 2025). The value is equivalent to an annualized amount of **26.28 million Euros** per year of additional social costs considering a 30-year impact assessment period. This translates to an annualized amount of **21.01 million Euros** over a 45-year period. These values do not account for qualitatively described impacts, such as public health and market effects.

TABLE 8: SUMMARY OF SOCIO-ECONOMIC IMPACTS INCURRED IN THE EEA IN CASE OF THE IMPACT ASSESSMENT SCENARIO.

Description of major impacts	**Monetised/quantitatively assessed/qualitatively assessed impacts**
1. Monetised impacts	**Value in million Euros [per year over 30 years] [per year over 45 years] [overall as NPV_{2025}]**
Foregone profits at manufacturers of gas and liquid fuels components	**[3.77] [3.01] [73.91]**
Additional one-off capital costs for decommissioning/replacing existing gas and liquid fuels components (NPV 2025)	**[2.50] [2.00] [49.01]**
The social cost associated with all job losses at manufacturers of gas and liquid fuels components	**[20.01] [16.00] [392.18]**
Sum of monetised impacts	**[26.28] [21.01] [515.10]**
2. Additional qualitatively assessed impacts	
Higher risks of shortcomings of gas and liquid fuels and thus disruptions of energy supply among the EEA consumer population and infrastructure	Not monetised
Reduced availability of consumer goods and increased prices for EEA consumers	Not monetised

5. Limitations and uncertainties

While a conservative approach was taken throughout the current assessment, there are several data limitations in the analysis which led to an underestimation of the monetized socio-economic impacts summarized in section 4.3.3.

As previously emphasized in sections 4.3.1.1, 4.3.1.2 and 4.3.1.2, appropriate data for the monetization of impacts (foregone profits, one-off costs and costs of unemployment) was only available in the context of the German figawa member companies relying on the use of fluoropolymer based components in GLF end products. No reliable data coverage for other EU member states under the scope of the current report could be made available. Therefore, the results can be regarded as exemplary for the EEA rather than area wide.

Furthermore, to maintain a conservative approach and in lack of appropriate estimates, no foregone profits occurring upstream in the value chain (e.g., at fluoropolymer producers and processors, input component manufacturers) were accounted towards the monetized impacts in this report. These effects are nonetheless expected to be large, thus leading to an underestimation of the results presented in section 4.3.3.

Finally, there was no data available for the monetization of further impacts on the EEA society associated with a lack of a time-unlimited derogation for the use of fluoropolymer-based components in GLF end products. In this sense, effects related to the increased environmental footprint, reduced security of gas, fuel and energy supply in general, and associated increased risk for all potentially affected public and private infrastructure could only be evaluated qualitatively.

6. CONCLUSION

In summary, the ramifications of a PFAS restriction, as determined by the socioeconomic evaluation, amount to approximately 515.10 million Euros (NPV 2025) or 21.01 million Euros per annum over a 45-year timespan.

Although the assessment solely incorporates contributions from figawa members included in the scope of this request, it is crucial to underscore the far-reaching implications of such a restriction, in the absence of the desired exemption, upon the entirety of the EEA society. This is particularly noteworthy as the repercussions of gas and fuel shortages due to the restriction are likely to create a ripple effect, touching upon public and private sector alike. In the absence of sufficient time to identify, test, and implement viable substitutes, disruptions stemming from hindered maintenance and repair procedures and installations of new systems are inevitably foreseen to cause supply chain disturbances.

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