DANISH TECHNOLOGICAL INSTITUTE

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The road to a PFAS-free future for Danish companies

Danish Technological Institute (DTI) is an independent, non-profit research and development institute approved as a GTS institute by the Minister for Higher Education and Science. Since 1906, DTI has worked to promote the utilization of technological advances for the benefit of industry and society through development, consulting, and dissemination. We fulfill this purpose by developing new knowledge through research and development activities, providing technological services on market terms.

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Look ahead, ahead! Look for the roads ahead that will pave the way for development and then place yourselves where you suspect the Institute's help will be necessary. The path will often take unknown routes and shortcuts, and detours cannot be avoided.

Gunnar Gregersen,
founder of Danish Technological Institute and director from 1906-1950

Three keypoints

For decades, PFAS have been a technological miracle cure. The chemicals make materials repel water, grease and dirt and are applied in everything from electronics to textiles. However, their strength is also the problem: PFAS do not degrade and therefore accumulate in the environment and in humans. Regulations are now being tightened globally. Especially in the EU, many applications are likely to be banned. Industrial companies must therefore be given the opportunity to act in time, which requires targeted support. Danish Technological Institute has three concrete proposals for action:

Acquire knowledge – make it easy to act

Danish companies need quick answers on where PFAS are used and what alternatives work in practice. We recommend establishing a national knowledge sharing platform where companies can find concrete cases, test results, and step-by-step guides for substitution. Danish Technological Institute is ready with cases, standards, and sector-specific advice as a basis.

Give companies the competence to develop alternatives

Small and medium-sized companies, in particular, cannot carry out the substitution work alone. A targeted support program could provide access to financial resources, testing facilities and impartial advice to enable more companies to develop, test, and document PFAS-free materials without significant risk. We have positive experience with network projects and can deliver best practice from concrete collaborations.

Enhance transparency in the value chains

Many companies unwittingly introduce PFAS through complex value chains. When manual traceability is inadequate, it makes sense to combine new technology, strong partnerships, and knowledge across industries. This creates collective solutions for the complex issue. With e.g. AI-driven tools to create overview, knowledge sharing and collaboration, solutions can be found across the value chain. This will strengthen responsibility, demand, and competitiveness in the market of the future.

Technological Outlook creates clarity in a complex landscape based on facts about technology, the market, trends, and mapping of players. We show the opportunities to strengthen the competitiveness of Danish companies through innovation, collaboration, and investment in technology. Our goal is to show the way to a groundbreaking, sustainable, and economically viable future. Let's build a better future together!

Juan Farré, CEO - Danish Technological Institute

> **PFAS regulation is tightening worldwide due to health and environmental concerns.**

Executive summary

The road to a PFAS-free future for Danish companies

PFAS – useful substances with major problems

PFAS are a large group of man-made chemicals that became popular because of their unique properties. They are water and grease repellent, electrically insulating and can withstand high temperatures and strong chemicals among many other beneficial properties. Therefore, PFAS are widely used in the industry – from textiles and electronics to food packaging and medical equipment. Unfortunately, these properties have also made PFAS a serious environmental problem, as the substances do not degrade naturally. PFAS are present everywhere in the environment now, from drinking water and rainwater to food and animal feed, and they accumulate in the human body. This increases the risk of a number of diseases such as cancer and fetal damage.

New, stricter, EU regulations on PFAS are on the way. Danish Technological Institute has written Technological Outlook to provide an overview of the PFAS issue and to support Danish industrial companies in making the transition to PFAS-free solutions in time. We see a growing need for knowledge, tools and technological guidance. Our goal is to translate complex knowledge into practical insights and inspire action, create an overview and indicate opportunities. The transition will promote both innovation and green competitiveness in Danish industry.

PFAS regulation – a complex global situation

Due to health and environmental concerns, PFAS regulation is tightening worldwide, but there is considerable variation in the pace and scope of the regulation. The EU is considering the most far-reaching proposal; a near-total ban on PFAS with few exceptions. If adopted, this will have enormous consequences for many industrial sectors. The United States and countries in Asia are also tightening regulations, but often with a more cautious approach that varies greatly between states and regions. This creates a complex situation for Danish export companies, which must navigate many different rules and limit values.

In Denmark, a ban has been imposed on PFAS in cardboard and paper food packaging, as well as in clothing and impregnating agents for private use. The regulation is not only putting pressure on Danish companies to quickly find alternatives but also giving them the opportunity to position themselves early in a market where demand for PFAS-free solutions is rising significantly.

Danish companies' experiences with PFAS

The report contains the results of a comprehensive survey of nearly 200 Danish industrial companies. The survey shows that approximately one in four companies uses (or has used) PFAS directly or indirectly through suppliers. More than a quarter of the companies do not know for certain whether their products or processes contain PFAS, which highlights the complexity of the long supply chains and significant knowledge gaps that exist in the industry.

The main reason to use PFAS is the unique technical properties of these substances. Many companies find it difficult to find alternatives that meet the requirements for performance, durability, price, and availability. Only a few companies have managed to substitute PFAS effectively, and many find that the existing alternatives are inadequate or involve technical compromises. Economics also plays a role; alternatives can be more expensive or require large investments in conversion and testing.

Among the companies that use PFAS, at least two out of three obtain PFAS primarily through subcontractors e.g., in materials, components or other items. Suppliers typically design components that can be used widely across customers and applications – and therefore choose PFAS to ensure robust performance across many parameters. At the same time, suppliers rarely know the specific end use and therefore do not receive the signals needed to develop targeted alternatives. On the other hand, users of the components feel that "there are no alternatives" because they do not know what else to ask for or which specific requirements they should communicate to the supplier. The result is a kind of Gordian knot; no one can or dares to make the first move.

Small and medium-sized companies, in particular, face challenges in identifying and implementing alternatives. They often lack specialized knowledge about substitution, and many depend on consultants and suppliers. This lack of internal expertise makes companies more vulnerable to tighter regulation. The survey covered industrial companies with 10 to 1,000 employees. A large proportion of Danish SMEs have fewer than 10 employees, and here it can be assumed that the lack of knowledge and expertise for PFAS substitution is even greater. The very large companies probably have stronger expertise, but there may be gaps in knowledge here as well.

Research into alternatives is growing – but the challenges are plentiful

Danish Technological Institute has mapped the scientific research into alternatives to PFAS through a detailed analysis of thousands of articles published between 2005 and 2025. This research focuses in particular on finding alternatives to properties such as water and oil repellency, heat resistance and chemical resistance. There has been a clear acceleration in the number of research projects, especially after 2015, reflecting increasing pressure from regulations and the market.

Proactive transition pays off

The report shows that Danish companies that actively phase out PFAS do it to meet legal requirements, as well as for ethical or strategic reasons. 65% choose environment and health as central driving forces and mention close collaboration with suppliers as a crucial factor to develop effective PFAS-free alternatives.

At the same time, the pressure increases on those that hesitate. Insurance companies are raising premiums significantly or declining coverage for companies using PFAS, and international liability cases are growing in magnitude. Big players such as 3M are withdrawing themselves from the PFAS market, which is creating uncertainty about supply and prices.

In short, Danish companies that lead the way with documented PFAS-free solutions can

Danish status of PFAS alternatives

	Status	Next step
9	**Science** With nine publications, DTU ranks Denmark among the active nations conducting research into alternatives. Focus on energy materials, membrane technology, and fluorine-free functional materials.	**Gather knowledge** There are many alternatives to PFAS. Companies lack knowledge, and knowledge is currently scattered. A national knowledge platform can provide companies with inspiration and access to knowledge about substitution.
1	**Technology** Technology for substituting PFAS is being developed by foreign chemical giants. One Danish company has patented a PFAS substitute.	**Build capacity for action** Targeted financial support, technological advice and access to testing can help the SMEs that lack the skills and knowledge for substitution.
33	**Market** 33 percent of Danish companies are experiencing demand from the B2B segment for PFAS applications. Demand is much lower from both private and public customers than from corporate customers.	**Increase transparency** New technology, strong partnerships and cross-industry learnings should be combined to create overview, knowledge sharing and collaboratively find solutions across the value chain.

differentiate themselves positively in both the domestic and export markets.

Proposed actions to support Danish companies in substituting PFAS

Danish Technological Institute has three concrete proposals for actions that can support Danish industrial companies in their efforts to substitute PFAS:

Acquire knowledge – make it easy to act

There are many opportunities to find alternatives to PFAS, but Danish companies need more than general warnings and regulations. They need concrete, practical knowledge that can be translated into action. Today, many companies find it difficult to find reliable information about where PFAS are found in their products and processes and which alternatives actually work. A national knowledge platform that collects and disseminates up-to-date knowledge about PFAS substitution is a good starting point. The platform should be easily accessible and target both technical staff and decision-makers in the industry. It should show how to identify PFAS in materials, what substitution solutions are available, how they are tested and documented, and what experiences other companies have.

Such a platform will not only provide information but also give companies the concrete tools they need to get started. Danish Technological Institute is ready with cases, standards, and industry-specific advice as a basis.

Give companies the competencies to act

Many companies are well aware that phasing out PFAS is necessary, but they lack the resources to do so. Small and medium-sized enterprises in particular do not have their own laboratories, development departments or materials specialists, and they take a substantial financial risk if they invest in poor alternatives. To make the transition possible, a targeted program could be set up to help companies develop, test and document PFAS-free solutions. This is not just about financial support, but also access to advice, testing facilities, and certification assistance. With the right competencies, companies can take responsibility and act proactively – not just to comply with the law, but to create better and more sustainable products. Such efforts will pay off in the form of increased competitiveness, export opportunities, and green transition.

Enhance transparency in value chains

Many companies' complex supply chains inadvertently introduce PFAS into their products. This happens through raw materials, semi-finished products and technical components, where PFAS are not always clearly visible in the data sheet. Therefore, a large proportion of industrial companies do not know whether they use PFAS. As a result, it is difficult for companies and their customers to be proactive.

To change this situation, efforts should be made to create more transparency in the whole supply chain. The PFAS challenge is complex and rarely solved by one player. Manual tracking of PFAS is often unrealistic, especially for larger companies with many products and an insurmountable value chain.

Cross-industry collaboration can create scale, lower the transaction costs, increase demand and make PFAS alternatives realistic (even for SMEs). Using collective solutions and new technology creates overview and a driving force simultaneously. A strategic effort to enhance transparency is based on close collaborations and open dialog. Strengthen communication with suppliers to find and handle the most obvious problems first. Exploit digital tools and AI to collect, structuralize and verify supply information, crosscheck documentation, prioritize testing activities and monitor changes in real-time.

When companies and their customers know what the products contain, it becomes easier to take responsibility and make active choices. This is good for the environment and strengthens competitiveness concurrently with increasing documentation requirements and focus on green procurement.

“ Companies need concrete, practical knowledge about which alternatives to PFAS are working.

Danish Technological Institute is ready as a PFAS sparring partner

Want to eliminate PFAS without compromising on quality and operations?
At Danish Technological Institute, we help companies like yours phase out PFAS and deal with PFAS contamination. We combine in-depth technical knowledge with the latest methods and provide you with solutions that work in practice – technically, economically and commercially.

Danish Technological Institute knows that alternatives exist for most of today's PFAS uses. But the challenge is rarely whether a substitute exists – it is finding the right solution for your specific product and production. Our job is to reduce complexity, test alternatives, and ensure that you can continue to deliver high performance – while strengthening your position in the market.

That is why companies choose us:

- Practical experience: We have helped everyone from niche manufacturers to global corporations find PFAS-free alternatives and deal with contamination. You gain access to knowledge about what works, where the pitfalls lie – and solutions that can be rolled out in practice.
- Strategic collaboration: We are more than just advisors. We are your sparring partner from initial analysis to implementation and anchoring. We ensure that you comply with legislation and strengthen your competitiveness – even when the market and regulations change.
- Strong network: With us, you gain access to laboratories, AI platforms and an international network of experts. This means that we can find solutions to complex challenges where substitution requires cross-sector collaboration.

Examples of solutions developed in collaboration with Danish Technological Institute:

- PFAS-free coatings for e.g., electronics, low-friction materials, anti-fouling and injection molding of plastic
- PFAS-free ball bearings with high requirements for low friction
- Technologies to remove PFAS I soil and water effectively
- Heat pumps with natural refrigerants without PFAS
- Mapping of PFAS in building materials
- PFAS-free textile impregnation (still under development)

Danish Technological Institute offers:

- Mapping PFAS-sorces: Identification and prioritization of areas of focus in production, supply and waste management.
- Help with substitution: Advice on alternatives and replacement materials to eliminate or minimize the use of PFAS in your product and identification of alternative suppliers.
- Purification technologies: Guidance on, and testing of, the most promising and effective technologies on the market for removing PFAS across industries.
- Advanced laboratory facilities: Opportunity to test technological solutions on a small scale, so that larger investments are only made after thorough testing and documentation.
- Specialists in PFAS across industries: Broad expertise in the environment, chemistry and process optimization.
- Innovation and development projects: Drive collaborations and development projects focusing on new methods and technologies for substituting and minimizing PFAS in construction, products, production or handling of PFAS contamination.

We accept your challenge: Do you have a PFAS challenge that no one has solved yet? Then, contact us! Turn the challenge around with us and let us show you that there is almost always a solution.

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Introduction

PFAS are a large group of incredibly useful chemicals. PFAS can, for example, help prevent fried eggs from sticking to the frying pan, keep hiking boots from getting soaked, make fires easier to extinguish, and improve the durability of the electronics in our computers. The usefulness of PFAS chemicals lies in their extreme durability and performance – but it is precisely these properties that cause them to be an environmental problem, as they break down extremely slowly. PFAS is therefore also called forever chemicals

PFAS accumulate in the environment and are found in sea foam on beaches, drinking water, rainwater, food, packaging, animal feed, clothing, makeup, etc. PFAS find their way into our bodies, lowering our immunity and increasing the risk of cancer and fetal damage. As a result, many applications are now being phased out. Strict regulations are on the way, and less harmful alternatives are being sought.

With increasing regulation on the horizon, a clear overview of both the challenges and the technological opportunities is needed. In Technological Outlook, Danish Technological Institute collects and disseminates knowledge about PFAS that can help Danish industrial companies find ways to phase out and substitute PFAS. The commercial potential will increase significantly in the coming years for the first companies to find alternatives.

The following is a brief introduction to PFAS and the regulation that is emerging. We have asked Danish manufacturing companies about their PFAS status and challenges, and, for inspiration, we present case examples from three Danish companies that have successfully substituted PFAS. We then turn to research and innovation to find alternatives to PFAS taking place around the world.

PFAS: The miracle cure

The story about PFAS began, coincidentally, in 1938. Chemist Roy Plunkett[1] from DuPont discovered a new substance while experimenting with refrigerants. The gas in a pressure cylinder had disappeared, leaving behind a waxy, white material with remarkable properties: It was smooth, chemically stable and extremely heat-resistant. The substance was named polytetrafluoroethylene (PTFE) and was later marketed as Teflon®.

PTFE was quickly adopted for industrial and military use, e.g. for seals and coatings in aircraft and nuclear reactors. Since then, a wide range of related fluorinated substances have been developed, including PFOA and PFOS, which can be used as surface-active agents, i.e. to repel grease and water.

PFAS became the modern miracle material used in waterproof and grease-repellent clothing and textiles, non-stick pans, fire-fighting foam, food packaging, medical equipment, and electronics. PFAS is the abbreviation for per- and polyfluoroalkyl substances, and PFAS today constitute a group of over 10,000 man-made chemicals,[2] characterized by their strong carbon-fluorine bonds. Their widespread use makes them a global environmental and health problem (A. B. Baun 2025).

[1] en.wikipedia.org/wiki/Roy_J._Plunkett

PFAS contain fluorine. Simply put, the definition of PFAS means that all PFAS substances have at least one carbon atom where all the spaces that would normally be filled with other atoms, such as hydrogen, are instead completely covered by fluorine. In the EU and Denmark, we follow the OECD's definition[3] from 2021, which is broader than previous definitions and includes more substances (A. B. Baun 2025, 21). The definition of PFAS varies globally. In this report, we use PFAS as an umbrella term that also includes, for example, PTFE, PFOA, PFOS, etc.

PFAS can be categorized into three main groups: soluble PFAS (also known as short- and long-chain PFAS), PFAS gases, and fluoropolymers. Soluble PFAS are often used in processes where water and oil repellency are important, e.g. impregnation of textiles. PFAS gases are found in refrigerants and certain types of medical equipment, while fluoropolymers such as Teflon (a type of plastic) are used in a great variety of products for many purposes. PFAS are widely used in processes and products across industries, including electronics/semiconductors, chemical production, the automotive industry, medical equipment, textiles, energy technology, and industrial machinery (Teknologisk Institut 2025, 6-7).

PFAS substances are often found in products with trade names that do not always directly indicate that they contain PFAS. Other PFAS were marketed intensively for many years and used in a wide range of products, including non-stick coatings for kitchenware, impregnation of textiles and carpets, water-repellent membranes for clothing and footwear, stain-resistant surfaces, breathable and moisture-repellent packaging, industrial lubricants and coatings, gaskets, surfactants, and fire-fighting foams.

The disaster behind the miracle

The downside of PFAS is serious consequences for both human health and the environment. PFAS degrades extremely slowly in nature and is also referred to as "forever chemicals". When PFAS end up in the aquatic environment, they can travel long distances.

Soluble PFAS are particularly problematic as they are easily absorbed by the body and can cause a number of health problems, including infertility, hormonal disorders, cancer, kidney problems, and birth defects (Sundhedsstyrelsen 2023, European Environment Agency 2025, Fenton, et al. 2021, Reddy 2023) .

Although fluoropolymers (the plastic type of PFAS) are generally considered safe during use, as they are not easily absorbed by the body, the production and disposal of these materials can lead to the release of harmful PFAS into the environment (European Environment Agency 2024). Microplastics from clothing and other textiles can also contain PFAS that potentially transfer to the skin. For example, a link has been found between the use of PFAS in firefighters' clothing and an increase in cancer-related deaths among firefighters, even though

[2] Other sources cite different figures, so the number of PFAS compounds also depends on the definition and counting method used. For example, in 2018, the OECD counted 4,730 PFAS-related CAS numbers. Baun also cites a study with more than 6 million PFAS, although it is unclear how many of these are actually produced (Baun, Limiting human and environmental exposure to PFAS in Denmark – Part 1: Identification of knowledge gaps. 2023). In the report, we use the figure "10,000" to indicate that there are a great many compounds. The Danish Environmental Protection Agency also uses the figure 10,000 (Danish Environmental Protection Agency, n.d.).

[3] Fluorinated substances containing at least one fully fluorinated methyl or methylene carbon atom (containing neither H/Cl/Br/I), i.e. PFAS are all chemicals containing at least one perfluorinated methyl group (-CF3) or one perfluorinated methylene group (-CF2-) (Danish Environmental Protection Agency n.d.).

the clothing has also made their work safer by reducing other types of deaths (Daniella 2025).

It is therefore important to be aware of the entire life cycle, from production to disposal, of products containing PFAS (European Environment Agency 2025, Baun, et al. 2023).

According to an estimate by the grassroots organization ChemSec, the total annual profit from PFAS for chemical companies is around $4 billion globally, which is not much compared to, for example, an annual profit of $77 billion in the United States alone for the entire chemical industry (Chemsec 2023). The societal costs of PFAS, on the other hand, are much higher: the Nordic Council of Ministers has estimated the health costs of PFAS in Europe at 52-84 billion euros, and soil remediation at 17,000 sites in Europe could cost up to 238 billion euros (Nordisk Ministerråd 2019).

The widespread use of PFAS in various products and the subsequent contamination of the environment make PFAS a societal problem that requires action.

Regulation is tightening – slowly

Globally, PFAS regulation is moving towards stricter control, but the pace and approach vary considerably. The first international regulation is more than 20 years old. Particularly, the EU and several US states are leading the way, while Asia is more cautious. Further regulation is on the way in various regions:

The Stockholm Convention

The Stockholm Convention on Persistent Organic Pollutants was adopted in May 2001 and entered into force on May 17, 2004. The purpose of the convention is to protect human health and the environment from persistent organic pollutants, also known as POPs (Miljøstyrelsen 2006). Globally, the regulation of PFAS substances has intensified in recent decades. In 2009, perfluorooctane sulfonic acid (PFOS) and its derivatives were included in the Stockholm Convention. Perfluorooctanoic acid (PFOA), as well as its salts and related substances, have also been subject to global phase-out through the Stockholm Convention. In June 2022, the parties to the Convention decided to include PFHxS and related compounds, which were subsequently added to the EU's POP Regulation that entered into force in August 2023. Perfluorinated carboxylic acids with longer chains (C9-C21 PFCAs) are under consideration for inclusion in the Convention and thus subject to global phase-out.

Despite the Stockholm Convention's ban on certain PFAS substances (PFOS, PFOA, PFHxS), the regulation covers only a fraction of the more than 10,000 substances that can be classified as PFAS.

EU – REACH and a total ban?

In the EU, the Stockholm Convention is implemented in the POPs Regulation,[4] and POP is supplemented by the REACH legislation,[5] which covers all chemicals more broadly. POP sets limits on the marketing and use of PFOS and PFOA, including their salts and related compounds, in substances, mixtures and articles. In February 2023, the EU restriction on the use of C9-C14 PFCA, its salts and related substances under REACH came into force (Miljøstyrelsen u.d.). Selected PFAS are regulated through several pieces of legislation in the EU. This applies to:

- The Drinking Water Directive: The Directive was revised in 2021 and introduces a limit value of 0.5 µg/L for the sum of all PFAS in drinking water.
- Food: PFAS are often used in food production, but not in applications where the food is expected to be contaminated with PFAS. Nevertheless, they often end up in food as a result of contamination from industry, PFAS pesticides and consumer products. In 2020, the European Food Safety Authority (EFSA) set a new overall limit for the four most problematic PFAS (PFOA, PFOS, PFNA and PFHxS) at 4.4 nanograms per kg of body weight per week. Exposure occurs mainly through fish, eggs, fruit, and derived products, and long-chain PFAS in particular tend to accumulate in the body (European Chemicals Agency u.d.). The Packaging Regulation prohibits the use of PFAS in food contact materials from August 2, 2026.
- Firefighting foam: A ban on PFAS in firefighting foam has been adopted. The date of entry into force is pending, and the ban will then be gradually implemented over a period of 18 months.

[4] POP: Persistent Organic Pollutants (EU) 2019/1021
[5] REACH: Registration, Evaluation, Authorisation and Restriction of Chemicals (EF) nr. 1907/2006

There are several nuances and exceptions for specific substances and applications, and new legislation is being introduced on an ongoing basis. The Danish Environmental Protection Agency maintains an overview on its website.[6]

Upcoming regulation from the EU?

Led by Germany, Denmark, the Netherlands, Norway, and Sweden, the EU has presented its most comprehensive proposal to date: an almost total ban on all PFAS, with certain temporary exceptions for technologies without alternatives (e.g. batteries or fuel cells). The proposal was sent to ECHA – the European Chemicals Agency, in January 2023, and is currently undergoing scientific evaluation. The process is slow. A large number of consultation responses (over 5,600) means that further delays are possible (Dadhania 2024, European Chemicals Agency u.d.).

A total ban on PFAS would directly and significantly affect several industries.

If the EU does not adopt the proposed restriction on all PFAS substances as a whole – or if the proposal is watered down or the principle of treating PFAS as a single chemical class is not recognized – there will be a significant need for more knowledge about the various subgroups of PFAS. In that case, it will be necessary to intensify research into the harmful effects of individual PFAS. In particular, there will be a need to develop and apply new toxicological screening methods that can quickly and effectively identify effects on the immune system and on fetal development in humans (Baun, et al. 2023).

Denmark

Individual Member counties may introduce stricter national legislation. In Denmark, the use of PFAS in cardboard and paper food pac-

Table 1. The Danish EPA's overview of Danish special legislation for PFAS as of May 7, 2025 updated according to legislation

Product	Legal text	Comments	Limit values
Food contact materials	Ban on cardboard and paper food contact materials from May 25, 2020	Permitted if migration to food is prevented	≤ 20 mg organic flour/kg paper
Firefighting foam concentrate for training purposes	Restriction on use, sale and import from November 7, 2023	-	≤ 1ppm (mg/kg)
Clothing, footwear and impregnating agents	Restriction on sale and import from July 1, 2026	Does not include products already regulated in the EU	≤ 50 mg F/kg

[6] www.mst.dk/erhverv/sikker-kemi/kemikalier/fokus-paa-saerlige-stoffer/pfas

kaging has been banned since 2020. The ban applies to materials used in contact with food, such as baking paper, pizza boxes and fast-food packaging. The textile industry is a major source of PFAS emissions, and this is now also regulated in Denmark on the consumer side. Denmark introduced a national ban on PFAS in clothing, shoes and impregnating agents for consumers from July 1, 2025, with a transition period for imports and sales until July 1, 2026. It is not legal for private individuals to import clothing, shoes, and impregnating agents containing PFAS through online marketplaces such as TEMU (Miljø- og Ligestillingsministeriet 2025).

USA

The federal government in the USA has no complete bans, but the EPA (US Environmental Protection Agency) regulates the presence of PFAS in drinking water and prevents the resumption of the use of phased-out substances.

In the USA, an approach has been chosen whereby companies must report their imports of PFAS. However, several states – including Maine, Minnesota, and California – are introducing much stricter legislation or bans on specific PFAS. The regulation of PFAS varies considerably from state to state. Some states have taken the initiative to ban PFAS in specific products, such as clothing and cosmetics, while others have implemented limits for PFAS in drinking water. This varying legislation creates a complex landscape for companies operating across state lines. NEWMOA (Northeast Waste Management Officials Association) has proposed model legislation that would harmonize state efforts with a broad ban on PFAS in consumer products. However, there are still differing views on the best approach to PFAS regulation in the United States, with some stakeholders arguing for targeted action against high-risk substances, while others prefer a total ban with exceptions for "essential" uses. This disagreement makes it difficult to predict the future direction of PFAS regulation at the federal level (Dadhania 2024, EPA 2025). The current political reality in the United States adds another layer of uncertainty and complexity to PFAS regulation: for example, the Biden administration set limits for some PFAS in drinking water as recently as April 2024, and the Trump administration wants to relax the limits (Perkins 2025).

Asia-Pacific region (APAC)

China, Japan, and South Korea comply with the Stockholm Convention to some extent. There are industry-specific initiatives, e.g. in South Korea which, in 2022, proposed banning eight PFAS substances in cosmetics (Dadhania 2024). In Japan, the production and import of PFOS was banned in principle in 2010 and of PFOA in 2021 through the Chemical Substance Control Law (CSCL). In February 2024, the same principled ban was extended to also include the production and import of PFHxS (Durlin, et al. 2025). In recent years, China has gradually tightened its regulation of PFAS, especially the most problematic substances such as PFOS and PFOA.

Since 2013, China has introduced restrictions on PFOS, and in 2019, PFOA and related compounds were also subject to phase-out requirements as part of the country's obligations under the Stockholm Convention. From 2024, the production, import, export and use of PFOS, PFOA, and their related substances are banned but with certain exceptions for essential uses. China has also launched national monitoring programs for PFAS in the environment and launched action plans to strengthen the regulation and phase-out of harmful chemicals. Despite these initiatives, certain PFAS are still used and produced, and significant pollution has been found in industrial areas, leading to increased focus on further regulation and control (Zhang, et al. 2024, ENVIROTECH u.d., OECD u.d.).

Shifting regulations challenge companies

The global variation in regulation is particularly challenging for Danish export companies that use PFAS. They may have to comply with many different regulations and limit values that will be subject to ongoing change in the coming years.

PFAS under scrutiny – insights from Danish industrial companies

At least a quarter of Danish industrial companies have or have had contact with PFAS, while more than one in four do not know whether they use it – often due to a lack of knowledge and complexity in the value chain. A minority have competences or experience with substitution, and small companies (in particular) are in a weak position. There is a big difference in readiness for change, depending on company size, industry, and functional needs.

Substituting PFAS is technically and economically challenging for many. Where alternatives exist, it typically requires collaboration with suppliers and internal development resources.

A ban on PFAS is expected to have significant consequences for some companies, particularly in terms of costs, technical adjustments, and certification. Others will be unaffected. Motivation for substitution is primarily driven by legislation, customer requirements, and environmental considerations – not economics.

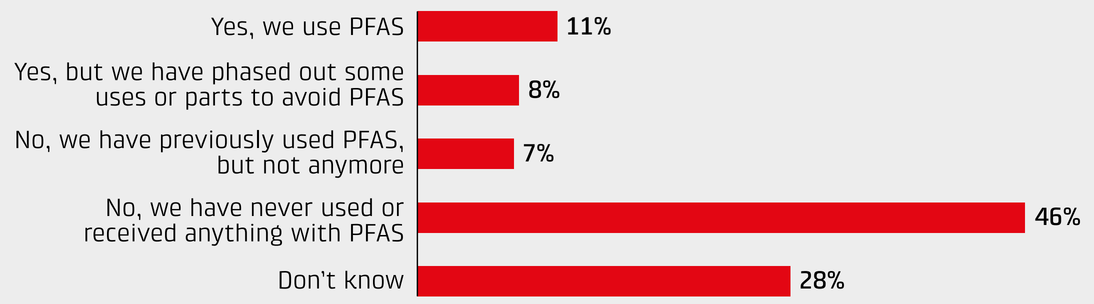
Many companies lack an overview of their use of PFAS and are calling for better knowledge, tools, and support. Effective phase-out requires targeted information, technical guidance, and clearer regulation – especially for smaller companies and indirect uses.

The following analysis is based partly on a survey conducted by Danish Technological Institute in spring 2025 among Danish industrial companies and partly on interviews for case descriptions. Senior employees from a total of 198 industrial companies with 10 to 1,000 employees responded to the survey, corresponding to a response rate of 17% (see Figure 1). PFAS can be a controversial topic for some, and others may know very little about the chemistry involved, which may explain the somewhat low response rate. In addition, a large proportion do not use PFAS or do not know whether they do and, for that reason, may have considered it irrelevant to answer questions about PFAS. The responses are weighted according to industry and company size, so they can be considered representative. Although, companies that use PFAS may be underrepresented in the survey.

In summary, the figures show a landscape where:

- One in five industrial companies uses PFAS.
- Some companies are actively phasing out PFAS.
- More than one in four companies are unsure/do not know whether they use PFAS.
- Almost half of the companies do not handle PFAS.

Figure 1. PFAS use in industrial companies



Question: Do you use or receive materials, products, equipment or production aids that contain PFAS?
Source: Survey, Danish Technological Institute (2025). **Note:** 196 responses – weighted by size and industry.

Overall, 26% of Danish industrial companies respond that they have had or have contact with PFAS, either currently or in the past: 11% currently use PFAS; 8% have replaced some PFAS, and 7% have used PFAS in the past but have stopped doing so.

46% of companies respond that they have never used or received anything containing PFAS. They consider PFAS to be irrelevant to their operations, either because they work in sectors where the substances are not used, or their suppliers do not supply materials or processes that require PFAS.

The remaining 28% are unsure ("don't know"). This points to considerable uncertainty and a lack of knowledge among companies, especially when it comes to indirect use via supply chains, materials or technical equipment. This may reflect the fact that PFAS are often invisible in practice; they are not always declared and can be technically difficult to identify.[7] This uncertainty is important in relation to both future regulation and information efforts.

This highlights the need for information, transparency in the supply chain, and technical guidance if the goal is a broader and more effective phase-out of PFAS in industry.

The competences in companies in relation to material selection and substitution of PFAS vary significantly, especially regarding company size. Across all 198 companies in the survey, just over half (56%) state that they have limi-

[7] The actual proportion of companies that use PFAS in their processes or products is difficult to determine for several reasons: Not all companies responded to the survey, and there was a high proportion of "don't know" responses, as well as some companies possibly using PFAS without being aware of it and therefore responding "No". As PFAS are "hidden" in processes and products, it is difficult to obtain information about them. In a screening of 1,894 industrial companies' websites, where Danish Technological Institute used scraping to obtain an AI assessment of the probability of PFAS use in the company, 3% were clearly "yes", 13% clearly "no" – and as many as 84% "possibly" – where the correct answer is therefore unknown and could be either "yes" or "no". Whether a company uses PFAS can therefore only be determined by mapping the individual company's processes and products.

ted or no knowledge of the area. This means that many companies lack the necessary knowledge to independently identify, assess, and implement alternatives to PFAS. Only about one in five companies have materials specialists on staff, and fewer than one in six have concrete technical experience with chemical substitution. However, almost one in four compensate for this by working with external consultants (see Figure 2).

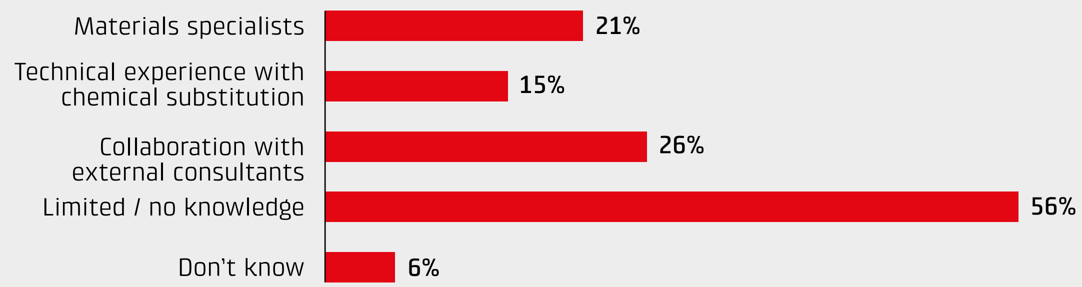
Internal expertise is essential. Among the companies that report using PFAS, 38% have their own materials specialists, while only 7% of the companies that do not know whether they use PFAS also have a materials specialist. Furthermore, 60% of the companies that have phased out PFAS collaborate with external consultants.

The competence gap between small, medium-sized and large companies is clear (see Figure 3). Small companies are in the weakest position. Larger companies are better equipped to handle a green transition and substitution of PFAS through internal resources and collaborations.

More than two out of three small enterprises say they have limited or no knowledge of material selection and substitution, and very few have access to relevant specialists or technical experience. They are either highly dependent on external assistance – or are completely unable to take active measures to address the challenges.

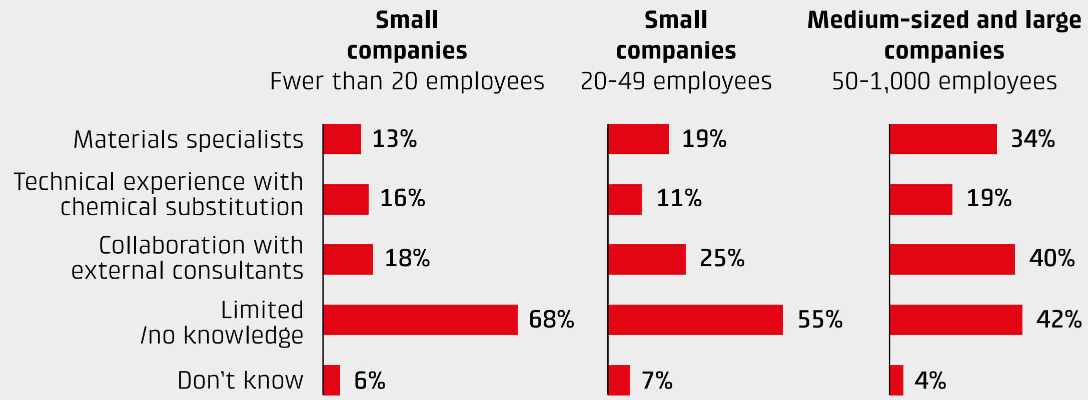
Medium-sized companies are doing slightly better, but over 55% still have limited know-

Figure 2. Competencies in material selection and PFAS substitution



Question: What internal expertise do you have in relation to material selection and PFAS substitution? **Source:** Survey, Danish Technological Institute (2025). **Note:** 196 responses – weighted by size and industry.

Figure 3. Competence in material selection and substitution of PFAS – by company size



Question: What internal expertise do you have in relation to material selection and PFAS substitution? **Source:** Survey, Danish Technological Institute (2025). **Note:** 196 responses – weighted by size and industry.

ledge, and only one in ten has experience with substitution. On the other hand, they have established collaborations with advisors to a greater extent than small companies.

The picture is significantly more positive for large companies. Here, as many as 34% have materials specialists, and one in five have specific experience with chemical substitution. However, the proportion that indicates a lack of knowledge is also high at 42%.

If there is a political and market desire for a broad and rapid phase-out of PFAS, it is necessary to support small and medium-sized enterprises with knowledge, competence building, and access to advice. In Case 1, the company CeramicSpeed talks about their work with materials to deliver high-performance ball bearings without the use of PFAS for lubrication. This development required collaboration with external consultants.

CASE 1 · CeramicSpeed

PFAS-free ball bearings strengthen the business at CeramicSpeed

A groundbreaking material with lower friction than Teflon has not only made CeramicSpeed's ball bearings PFAS-free, it has also opened the door to new markets and a unique market position.

From the food industry to high-end bicycles

For years, CeramicSpeed has been supplying high-performance ball bearings for cycling, motorsports and industrial applications, among other things. The company's bearings are known for their ability to rotate at up to 40,000 revolutions per minute with extremely low friction and a long service life.

A special product area is the company's SLT (Solid Lubricant Technology) bearings, which differ from traditional bearings in that the lubricant is integrated into the bearing's construction. Instead of oil or grease (that needs to be reapplied), SLT bearings contain a plastic matrix that forms pores filled with oil when heated. The oil is gradually released during use, ensuring maintenance-free lubrication.

However, the technology is sensitive to balance. "If the oil comes out of the bearing too quickly, there will be a puddle of oil, and the bearing will not last very long. Conversely, if it holds the oil too tightly, it will not get enough oil to lubricate," explains Lina Søbjerg Madsen, IPR specialist and chemist at CeramicSpeed.

Proactive phase-out of PFAS

Although legislation did not yet require it, CeramicSpeed made an early decision to phase out PFAS, including Teflon (PTFE), from their products. The decision was made based on a strategic desire to combine sustainability with technological innovation.

"We are very committed to using chemicals that are as green and non-harmful as possible," says Lina Søbjerg Madsen. "Even though legislation did not yet require it, we saw it as an opportunity to stay ahead of future regulations."

However, the company faced a challenge: how to replace a substance with friction properties as effective as Teflon without compromising performance?

Systematic collaboration leads to a breakthrough

After unsuccessful attempts to find a suitable alternative, CeramicSpeed initiated an MUDP-supported collaboration with Danish Technological Institute. It was a process that combined the company's in-depth product knowledge with the institute's expertise in materials technology.

"We had tried to find alternatives ourselves, but realized that we needed a more systematic approach," explains Lina Søbjerg Madsen. "In collaboration with Danish Technological Institute, we were able to define exactly what properties we needed, while they contributed their knowledge of materials technology."

The development process followed a methodical approach: First, a collaborative requirement specification was formulated. Next, Danish Technological Institute identified 18 potential materials. Eight of these were selected for testing. Ultimately, the most promising material was implemented in production.

"The process we ran is typical of the way we approach and develop a new alternative," says

Peter Nørby from Danish Technological Institute. "When we talk about PFAS, it is important to clarify what the company actually needs. In other words, which properties are important for the functionality of the product."

Less friction – greater potential

The big breakthrough came when the new PFAS-free material not only proved to match Teflon but significantly surpassed it. "We achieved up to 30% less friction with the new material compared to PTFE," says Lina Søbjerg Madsen. "That was something we hadn't expected at all when we started the project."

This groundbreaking result changed everything. SLT bearings, which had previously been used primarily in the food industry, could now also be used in high-end bicycles – a demanding market where friction and maintenance are crucial parameters.

Unique technology creates competitive advantage

With the new material, CeramicSpeed has created exclusive technology that has significantly strengthened the company's position. The products are now used in handlebars and other components in premium bicycles.

"We are the only company that can make these bearings for bicycles, and the bicycle manufacturers who have tested them have returned with positive feedback and a desire to implement them in their products," says Lina Søbjerg Madsen.

The new bearings offer customers longer life and significantly less maintenance, and CeramicSpeed now offers a lifetime warranty on selected products. The shift is therefore not only an environmental gain, but also a direct strengthening of the business.

Learning: Innovation takes time – and requires collaboration

During the project, CeramicSpeed gained a number of key insights. First and foremost, the company's own assumptions were challenged: "We discovered that our assumptions about how friction reduction worked in the bearings were not entirely correct. This opened up new material choices."

At the same time, it became clear that there is no universal solution for PFAS substitution: "You have to do a technology study for each application."

Product development also proved to be more time-consuming than expected: "Finding a replacement for PFAS is one thing. How the new raw material affects the product is another. We ended up rethinking the entire manufacturing process, and it took four years to reach our goal."

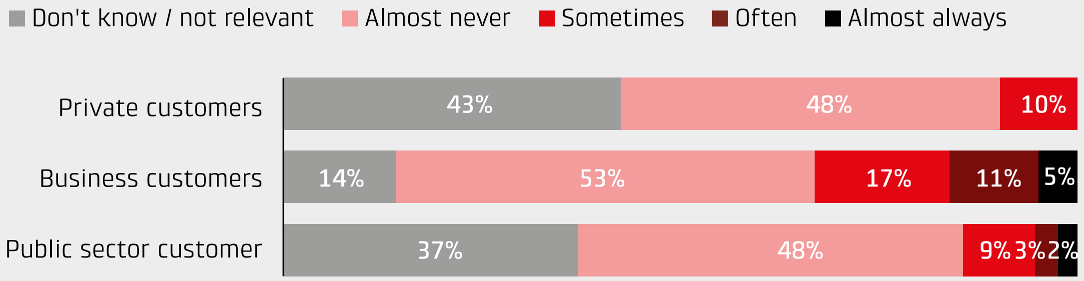
Finally, the collaboration with Danish Technological Institute proved crucial. "The collaboration gave us access to specialized knowledge and a systematic approach that we could not have achieved on our own," says Lina Søbjerg Madsen.

A green and strong future

Following the successful phase-out of PFAS in their SLT bearings, CeramicSpeed is looking at new opportunities. Several bicycle manufacturers have already tested and approved the new bearings for their models.

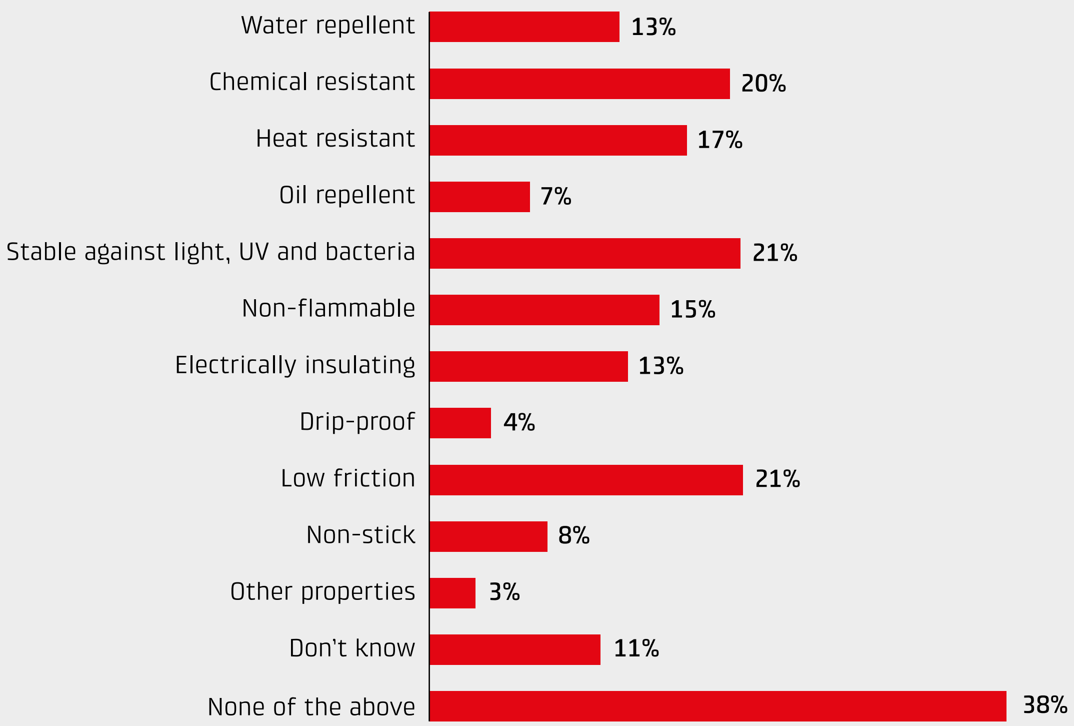
"We have created a product that is not only environmentally sound, but actually performs better than the previous one," concludes Lina Søbjerg Madsen. "This shows that sustainable innovation can be a direct route to business development and new market opportunities."

Figure 4. Customers rarely ask questions about a company's use of PFAS



Question: To what extent do customers or authorities ask you about your use of PFAS? Responses broken down by company market. **Source:** Survey, Danish Technological Institute (2025). **Note:** 190 responses – weighted by size and industry.

Figure 5. Functional properties of PFAS that companies use



Question: Which functional properties are important in relation to your products, production and materials – regardless of whether you use PFAS or alternatives? Please tick more than one box if relevant. 16 percent ticked only one box. The rest ticked more than one. 9 percent ticked five or more boxes. **Source:** Survey, Danish Technological Institute (2025). **Note:** 196 responses – weighted by size and industry.

Eight out of ten companies that responded are B2B companies, i.e. subcontractors to other companies, and just under one in five supply the public sector. Half of the companies have a strategy or policy for chemical substitution, and 38% have previously worked with chemical substitution.

Very few industrial companies find that customers ask about the company's use of PFAS. Questions typically come from business customers, while private consumers are rarely active. Somewhat surprisingly, public sector customers are also not particularly active in making demands and asking questions about PFAS – considering that environmental considerations in public procurement have been part of Danish environmental protection law since the late 1980s (see Figure 4). Just as companies need to find ways to adapt, it may be useful to give consumers, companies and public authorities better conditions for making demands – e.g. through labeling schemes or other forms of documentation.

The industrial companies have a widespread need for the functions that PFAS can offer in their products, production, and materials (see Figure 5).

Companies that use PFAS

Among the companies that responded "Yes, we use PFAS" (Figure 1), one in four (23%) primarily use PFAS themselves, two out of three (63%) primarily obtain PFAS via subcontractors – e.g. in materials, components or other items, and 11% use it themselves and via subcontractors, while 3% do not know.

The main reasons why companies use PFAS are that the substances meet the technical requirements for the products. In addition, there are customer requirements and requirements from authorities (see Figure 6). At the same time, many companies experience that they do not have control over the use of PFAS because the substances are largely supplied by subcontractors. As one company puts it: "We have no influence on the manufacture of electronics". Others point out that consumption is closely linked to the company's processes or products: "[PFAS] fit the use we have in our production processes" and "Friction and non-stick cannot currently be achieved in any other way".

The above quotes emphasize that suppliers typically design components that are to be used widely across customers and applications. Therefore, they often choose PFAS to ensure robust performance on many parameters. At the same time, suppliers rarely know the specific end use, and therefore, do not receive the signals needed to develop targeted alternatives. On the other hand, users of the components feel that "there are no alternatives" because they do not know what else to ask for or what specific requirements they should communicate to the supplier. The result is a kind of Gordian knot. No one can, or dares, to make the first move.

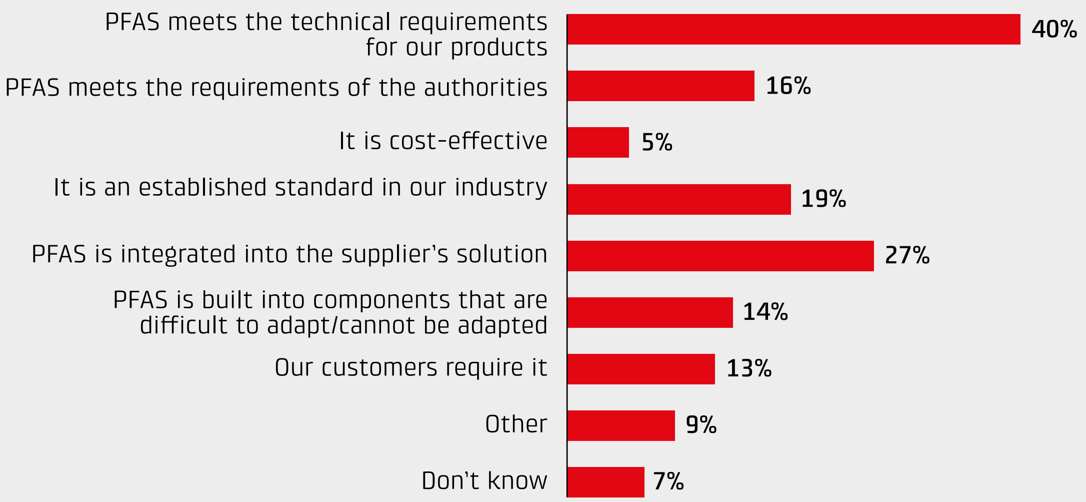
Therefore, the advice to companies is not just "communicate better with your suppliers", but "communicate about the right things in a way that makes new solutions possible". This requires companies to specify and share their contexts of use, function requirements, and quality requirements (e.g., temperature, chemical exposure, service life, friction, barrier properties) and to distinguish between "must-have" and "nice-to-have". Suppliers thus receive clear market signals to develop PFAS-free alternatives, while customers have something to test against. The dialogue can be strengthened through joint testing processes, data searching, and rapid iterations. Knowledge-sharing barriers can be reduced through NDAs and clear roadmap agreements (what should be able to do what and when).

Such a specific and targeted supplier dialogue reduces risk, opens up real alternatives, and creates the necessary conditions for PFAS to be phased out without compromising performance.

The companies believe that there are sometimes, but not always, alternatives to using PFAS. In Figure 7, the companies have assessed alternatives to PFAS based on functionality, price, durability, environment, health, and availability.

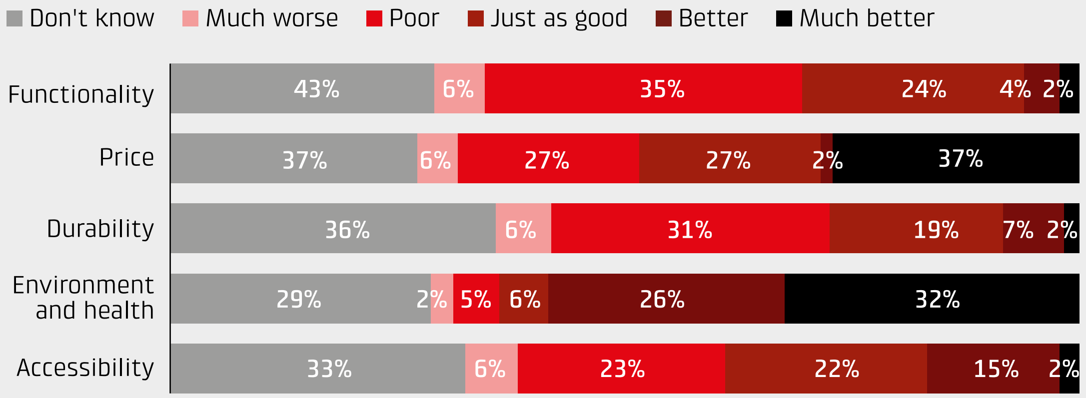
The main impression from the table is that a large proportion (29% to 36%) do not know enough about alternatives to be able to answer

Figure 6. Why are PFAS used in the company?



Question: Why do you use PFAS? Please tick more than one box if relevant. Only those who use or have used PFAS. **Source:** Survey, Danish Technological Institute (2025). **Note:** 50 responses – weighted by size and industry.

Figure 7. Assessment of alternatives to PFAS



Question: How do you assess alternatives to PFAS in relation to these parameters – either based on experience or expectation? Those who use or have used PFAS. **Source:** Survey, Danish Technological Institute (2025). **Note:** 50 responses – weighted by size and industry.

the question. And on most parameters, companies respond that the alternatives are much worse or worse on almost all parameters except for environmental and health, where more than half respond that the alternatives to PFAS are at least as good, if not much better. However, for the other parameters, only a small proportion believe that the alternatives to PFAS work better, are cheaper, extend durability or are more available. When it comes to price, almost two out of three companies experience that alternatives to PFAS are available at the same price or cheaper.

In response to an open question about whether companies are aware of alternatives to PFAS within their industry, the answers paint a mixed and nuanced picture of the opportunities. A few companies have been successful in finding usable or partially satisfactory alternatives, particularly in connection with rubber products and paper processing, where grease and water-repellent properties can be achieved without PFAS – often, however, with compromises in terms of performance or durability. Specific examples are also mentioned where companies have initiated testing of new PFAS-free products and, in some cases, the switch is already underway in production.

At the same time, it is clear that many companies are experiencing major barriers to substitution. They point to technical challenges such as reduced chemical resistance, shorter service life, and problems with metal release in food contact (particularly in applications such as cast iron, lubricants, and special coatings). Several companies state that they either do not know of any alternatives, do not believe they exist, or have searched for a long time without finding acceptable replacements. Particularly in areas with normative regulation or high functional requirements, such as electronics, agricultural components and surface treatment, it is mentioned that changes would require extensive testing, regulatory approvals and potentially new certifications, which would make it time-consuming and resource intensive.

A few companies express a general ambition to avoid PFAS, e.g. in the textile industry, while others are working purposefully on substitution but are still awaiting market-ready solutions. In general, the responses indicate that promising alternatives are available for some applications, but that there are still major gaps where technological development and regulatory clarification are needed to enable phase-out. Substitution of PFAS is thus underway in several places, but for the vast majority it remains a technical and practical challenge rather than a clear opportunity.

A forthcoming ban on PFAS is assessed by companies that use or have used PFAS as a change that will affect their business activities to varying degrees – albeit with considerable variation in both severity and adaptability (see Figure 8).

Approximately a third of companies indicate that they will incur higher costs as a result of a ban, while just under a third assess that they will have to adapt processes or equipment. In addition, a small but not insignificant proportion emphasize that they will have to make significant changes to their products (11%), experience delivery problems (28%) or have difficulty meeting customer requirements (19%).

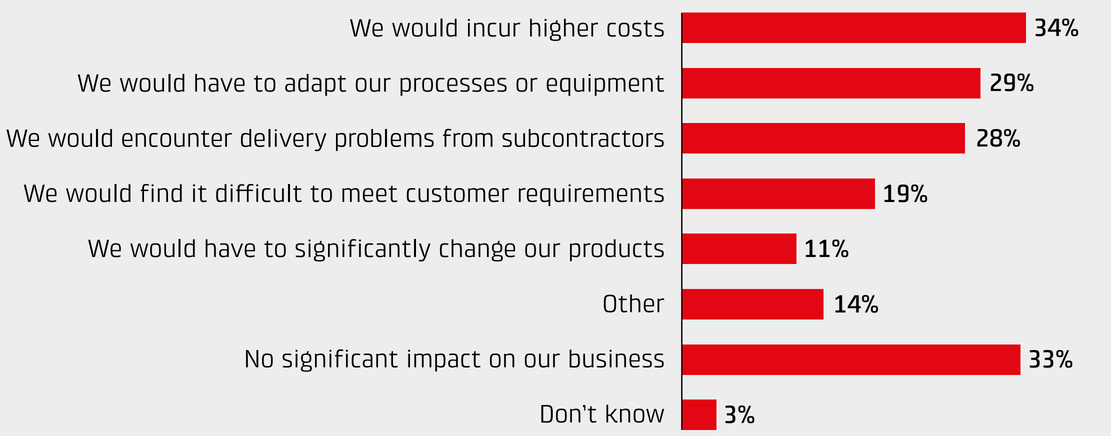
At the same time, one in three companies assesses that a ban will not have a significant impact on their business, which indicates a certain robustness and/or low dependence on PFAS among a significant proportion of respondents.

The qualitative responses in the "other" category provide a more detailed insight into specific concerns. Among other things, it is mentioned that a ban would make it difficult to meet applicable product standards and chemical protection requirements, such as EN 13034. For some companies, it would be difficult to comply with UL and Functional Safety requirements, which could have consequences for exports and international deliveries. The recertification of several product groups is also mentioned as a burdensome process. A few companies point out that they have already phased out the purchase of PFAS-containing fabrics but still have PFAS products in stock, which testifies to the challenges of transition.

However, one response highlights that a ban could be positive because it would push companies to find solutions that they would not otherwise seek out themselves. In other words, regulation can also be a driver for innovation and technological change. But customer demands can also be motivating; in Case 2, the company Micro Matic explains that it was customer demand that prompted them to start looking for alternatives. So, in that case, the products have been changed precisely because of customer demand.

[8] EN 13034 is a European standard for protective clothing that provides protection against liquid chemicals, especially splashes and sprays.
[9] UL (Underwriters Laboratories) is a global organisation that certifies products, processes, materials and systems to ensure that they meet safety standards. UL certification is often a requirement for marketing products in North America, especially in the United States and Canada.

Figure 8. Consequences of a ban on PFAS



Question: What would a ban on PFAS mean for you? Please tick more than one box if relevant. Only those who use or have used PFAS. **Source:** Survey, Danish Technological Institute (2025). **Note:** 50 responses – weighted by size and industry.

CASE 2 · Micro Matic

Gradual phase-out due to customer pressure – PFAS management at Micro Matic

Micro Matic is working on the gradual substitution of PFAS, driven primarily by customer demand rather than legislation. The focus has been on replacing PFAS in rubber and plastic (with plastic, in particular, presenting technical challenges). The substitution is being carried out in a pragmatic and market-oriented manner, but obstacles such as a lack of alternatives, testing capacity, and knowledge are slowing down the process.

Micro Matic is an international supplier of beverage tapping equipment and is the market leader in valves, couplings, regulators, and installation elements for beer and soft drinks. The company operates globally and supplies markets with high regulatory requirements and sectors with a focus on hygiene and operational safety. The products must be able to withstand everything from heat and steam to aggressive cleaning agents, which places high demand on the chemical and mechanical properties of the materials.

Product specialist at Micro Matic, Morten Winther, presents Micro Matic as a company where work with PFAS is primarily driven by customer requirements and a practical approach. The process is characterized by gradual substitution, technical compromises and dependence on suppliers.

From customer pressure to concrete action

It was not legislation but inquiries from American customers, that first put PFAS on the agenda at Micro Matic. Since then, customer questions and expectations have been the main driving force behind the company's work with substitution. According to product specialist Morten Winther, they find that customers are often ahead of the authorities in their demands – and thus, the real pressure comes from the bottom of the value chain.

Focus on rubber and plastic

The company's work on phasing out PFAS has focused on two main areas: rubber components and plastic items. In the rubber sector, PFAS-containing Viton seals have been replaced with nitrile rubber – a process that, according to Morten Winther, has been relatively straightforward, as nitrile was able to meet the same requirements in this case. In the plastics area, however, the challenges are greater. PFAS-based coatings, such as Teflon have, so far, been used to reduce friction in moving parts, but the company has not yet reached its goal in this area.

A specific problem arose when a subcontractor in Denmark had to shut down production of Teflon-coated items, leaving Micro Matic without a clear alternative. They are now faced with the choice of finding new types of coatings, new plastic grades, or completely changing the design of their products.

Complex material requirements

PFAS is used in components that must be able to withstand a combination of pressure, heat, chemicals, and food contact. This makes substitution difficult. According to Morten Winther, it is rarely a one-to-one replacement, but more often, it is a compromise between function, price, and durability. Some of the PFAS-containing auxiliary materials, such as Teflon tape, are difficult to substitute even though they are not included in the final product, thus creating a grey area between operation and documentation.

Substitution as a competitive parameter

Although the company has not yet fully phased out PFAS, PFAS-free products are already being actively used in marketing to customers. "If we can say that we have products without it, then we say so," he says. PFAS status is becoming a competitive parameter – especially in segments where product price plays a lesser role than safety and compliance.

Perspectives and experiences

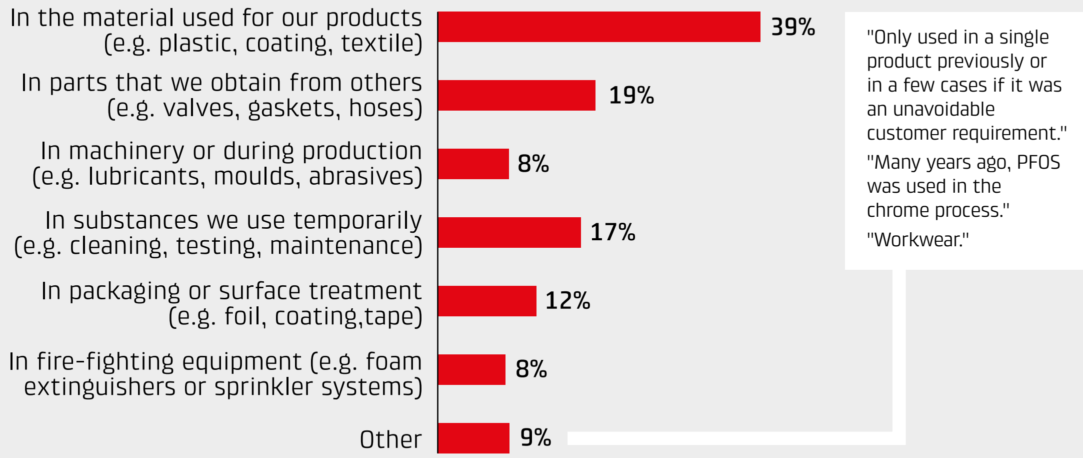
The company's approach has been pragmatic and stepwise. There has not been an overall strategy from the beginning, but rather a recognition of necessity. The process is largely driven by feedback from customers and suppliers, and experience points to the need for better information channels and access to substitution knowledge. Morten Winther also highlights the lack of societal support to navigate complex regulations and ensure access to reliable testing capacity and substitution guidance – especially for smaller companies.

Companies that have found alternatives

Among the companies that have found alternatives to PFAS (Figure 1), they have particularly done so for the materials for their products – e.g., plastics, coatings or textiles (see Figure 9).

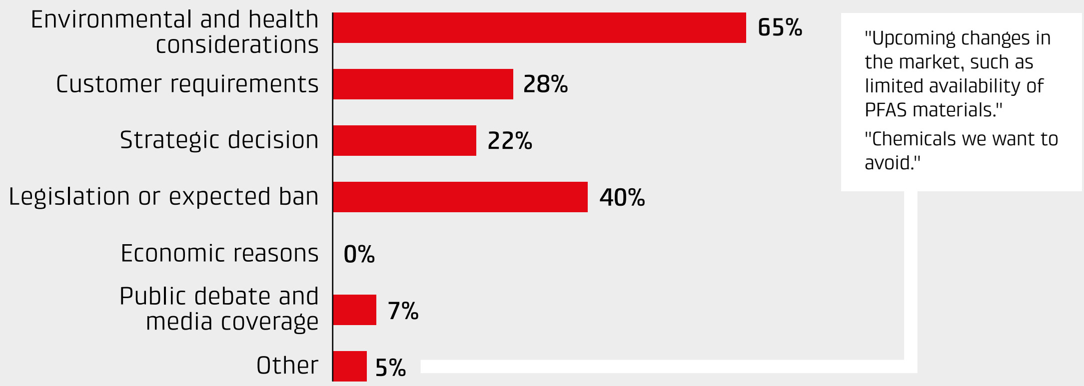
The study does not reveal which alternatives have been found, and it is not clear whether the alternatives are better than PFAS regarding the environment and health. A Danish study mentions that PFAS are often substituted by choosing another PFAS instead. For example, by switching from long-chain to short-chain PFAS, but this does not alleviate the problem as these are still persistent, mobile and toxic substances (Baun, et al. 2023) .

Figure 9. What alternatives to PFAS have companies found?



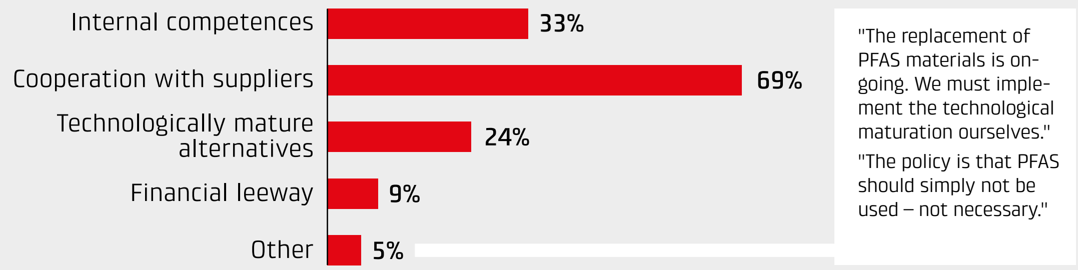
Question: Where did you previously use PFAS, for which you have now found alternatives? Please tick more than one box if relevant. Only those who have completely or partially phased out PFAS. **Source:** Survey, Danish Technological Institute (2025). **Note:** 29 responses – weighted by size and industry.

Figure 10. Motivation for finding alternatives



Question: What prompted you to look for alternatives to PFAS? Please tick more than one box if applicable. Only those who have completely or partially phased out PFAS. **Source:** Survey, Danish Technological Institute (2025). **Note:** 29 responses – weighted by size and industry.

Figure 11. Prerequisites for switching from PFAS



Question: What were the prerequisites for making the switch from PFAS possible? Please tick more than one box if relevant. Only those who have completely or partially phased out PFAS. **Source:** Survey, Danish Technological Institute (2025). **Note:** 29 responses – weighted by size and industry.

The motivation to seek alternatives to PFAS is largely driven by environmental and health considerations (see Figure 10). Two out of three companies that have found alternatives choose environmental and health considerations as a key reason, making it the most common driver. This is followed by legislation or expected bans (40%) as an important factor. Companies are therefore not only acting out of a desire for responsibility, but also out of a need to comply with existing or future regulations. With stricter legislation, legislation is expected to become a stronger driving force.

Strategic decisions also play a role (22%), suggesting that some companies are proactively trying to future-proof their products and business models independent of external regulations. At the same time, 28% say they are under pressure from customer demands, indicating that the demand for PFAS-free solutions is beginning to apply to the market, albeit not universally.

Making changes costs money, and therefore economics is not the primary motivation for anyone to phase out PFAS, but there are examples of how phasing out can create a better product and strengthen competitiveness (see Case 1: CeramicSpeed).

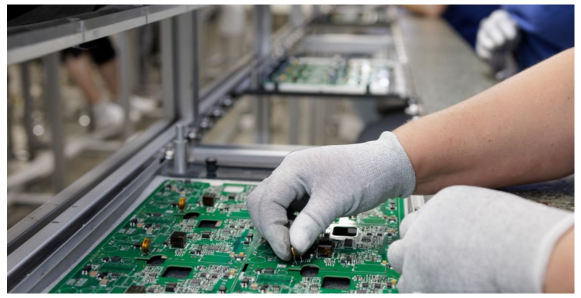
Public debate and media attention are mentioned by 7% and thus play a certain (limited) role in the decision-making process. This suggests that although PFAS has received increasing attention in the public debate, it is not the primary driver of action for the companies.

Under other, two points are mentioned that supplement the picture. Firstly, reference is made to future market conditions, such as limited access to PFAS materials. Secondly, a more value-based point of view is referred to. PFAS are simply referred to as “chemicals we want to avoid”. This shows that a normative awareness and willingness for responsible substitution beyond specific external requirements exists.

The desire to find alternatives to PFAS is primarily driven by responsibility and necessity; environmental considerations and regulation being the most weighty factors. It should also be emphasized that relatively few companies have found alternatives to PFAS.

The companies particularly highlight cooperation with suppliers as the most important reason why substitution has been possible. This is mentioned by as many as 69%. This shows that the supply chain plays a key role in the transition in terms of technological knowledge, access to materials, and product development (see Figure 11).

In addition, 33% point to internal competences as a crucial factor. This suggests that companies themselves have technical or chemical knowledge, which they have been able to bring into play to identify and test alternatives. At the same time, it shows that substitution is,



often, not just a matter of replacing one substance with another but also requires development work and specialist knowledge.

Only 24% believe that technologically mature alternatives have been available, which emphasizes that the market for PFAS substitutes is still developing and that solutions are often not readily available. Even fewer (9%) indicate financial scope as a significant factor.

Under "other", there are at least two different perspectives: one response describes the replacement as being in progress, but that technological maturation must be carried out internally, which points to a development task rather than a finished solution. Another response problematizes the fact that PFAS phase-out is based on politics and principles rather than technical necessity.

The companies that have partially or completely phased out PFAS report that PFAS substitution is typically successful where there are close relationships in the value chain and technical resources within the company itself. As many as 69% have collaborated with their suppliers. Market-ready solutions are available in some cases but by no means all. Economics alone is rarely a decisive factor. Instead, competences, collaboration, and technological development drive the change.

Companies that have switched completely or partially experienced a number of significant barriers in the transition to alternatives to PFAS. The most common barrier was a lack of knowledge among suppliers, which was mentioned by 44% of the respondents. This emphasizes that companies are often dependent on external actors in their value chain and that substitution is therefore not solely an internal issue. It requires cooperation and technological maturation with suppliers.

Next, technical challenges (41%) and increased costs (35%) are highlighted as key barriers. This reflects the fact that alternatives to PFAS often involve compromises in terms of performance, production processes, and economics. At the same time, just under a third (29%) indicate that there is a lack of knowledge within the company, which again highlights the need for upskilling and technological support, especially in small and medium-sized enterprises.

A lack of prioritization by customers is mentioned by 15%, which again emphasizes that the market does not always actively demand PFAS-free alternatives – and thus does not reward companies that invest in substitution. Internal resistance is only mentioned by a very few (3%), which suggests that reluctance rarely comes from within.

The qualitative comments in the "other" category add important nuances:

- It is pointed out that substitution requires changed product specifications and that production and customers must be willing to accept changes in product properties.
- One company mentions that the process is hampered by the costs and time involved in recertification, which is particularly true in normative industries.
- Others experience resistance from outside, e.g., in the supply chain or market.
- Some have found it easier to explain to customers that PFAS-free products are acceptable when requirements and functionality are clearly stated.
- Finally, it is mentioned that there was previously a lack of awareness of the problematic properties of PFAS, and that their use was considered the best technical solution – without being challenged.

The barriers were technical, economic, and knowledge-related – and often rooted throughout the value chain, not just in individual companies (see Figure 12). To ensure a broad phase-out of PFAS, there is therefore a need for knowledge sharing, customer dialogue, supplier collaboration and regulatory clarity.

The shift to alternatives to PFAS has had significant consequences for some companies, while others have been affected only to a limited extent.

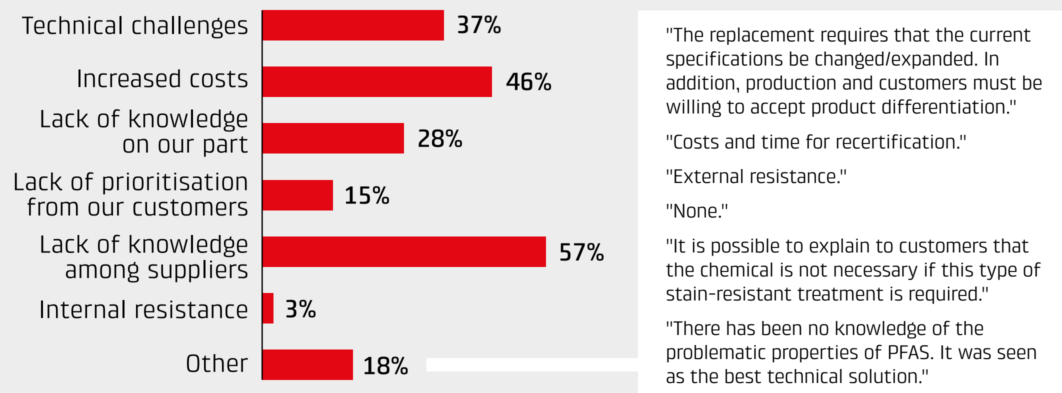
The most widespread consequence of switching to alternatives to PFAS has been higher costs (see Figure 13). In addition, 16% have had to adapt their production processes or equipment, and 9% have had to significantly change their products, showing that in some cases the changes go deep into the core services of the company.

Further, 23% have had to change subcontractors, which emphasizes that the availability of PFAS-free alternatives is not uniform in the supplier market and that companies that want or need to phase out PFAS may have to look for new partners.

On the other hand, 21% state that the change has not affected them significantly, and 15% that it has had no impact at all. This suggests that a significant proportion of companies have either had a relatively easy path to substitution – perhaps because PFAS was only used peripherally in their products or because they had already chosen PFAS-free solutions.

Only 4% answered "don't know", which indicates that most have a clear picture of what the consequences have been for their own operations.

Figure 12. Barriers to phasing out PFAS



Question: What barriers did you encounter when switching to alternatives to PFAS? Please tick more than one box if relevant. Only those who have completely or partially phased out PFAS. **Source:** Survey, Danish Technological Institute (2025). **Note:** 29 responses – weighted by size and industry.

Figure 13. Consequences of the switch to alternatives

Question: What has the switch to alternatives to PFAS meant for you? Please tick more than one box if relevant. Only those who have completely or partially phased out PFAS. **Source:** Survey, Danish Technological Institute (2025). **Note:** 29 responses – weighted by size and industry.

Substituting PFAS is not without consequences for a large proportion of companies, but the extent varies. For some, it involves technical and economic adjustments and new supplier choices. For others, it has had only limited or no impact. This reflects both the variation in the role of PFAS in production and the adaptability of the companies.

Phasing out PFAS can be costly and technologically difficult. Gastrolux explains this in Case 3. Nevertheless, it was commercial considerations that put Gastrolux on the trail of alternatives, so that being PFAS-free could become the competitive advantage that Gastrolux has today by switching before its competitors.

CASE 3 · Gastrolux

From core product to competitive parameter – PFAS phase-out in global niche production

Gastrolux manufactures pots and pans for the high-end segment and exports 150,000 units annually to over 25 countries – particularly in Europe, Asia and North America. For over 20 years, production has used a surface treatment called Biotan, which was originally free of PFOA and PFOS, but not necessarily other PFAS. In recent years, the company has developed a new PFAS-free version based on a silicone coating called evo, in close collaboration with a German supplier.

In an interview with CEO Henrik Møller Jensen, he describes the work with PFAS substitution as driven by consumer demands and characterized by particularly technical compromises.

Customer expectations as a lever

Gastrolux chose to develop PFAS-free products primarily for commercial reasons. Consumer awareness of PFAS means that "PFAS-free" has become a decisive factor in the choice of kitchen equipment, even when the differences in use are marginal. As large retail chains, especially in France and the United Kingdom, began to demand PFAS-free products, substitution became a necessity in order to maintain market access.

Technical challenge: the non-stick effect

The biggest technical barrier has been developing a coating with equivalent performance. The new silicone-based evo coating has the advantage of being resistant to metal utensils and more durable than fluorine-based coatings, but the non-stick effect is significantly weaker. This is seen as a compromise: "It's still good, but it's not as good on PFAS-free as on our core product – and I don't think we'll ever achieve that," says Henrik Møller Jensen.

Production restructuring and resistance to change

The PFAS substitution has led to extensive changes in production. The transition to new surface treatment required investments in new technology and adaptation of work processes.

Economic and regulatory barriers

The development and documentation of the new product have been expensive. Not only because of the materials, but especially because of the many requirements for new approval, including municipal environmental permits and EIA examinations. These procedures are perceived as costly and bureaucratic. This is particularly because it is still unclear which specific regulations will apply in the future.

At the same time, the new product requires new product lines and double stocking, because certain markets (e.g., in Asia) continue to demand the original Biotan coating. Maintaining two product lines is an additional operational burden that cannot be eliminated until global demand changes.

Uncertainty about control and quality

A surprising barrier has been that even products manufactured with PFAS-free coatings

could be contaminated during packaging or transport. This happened, for example, with a delivery to Taiwan, where PFAS was measured in an otherwise documented PFAS-free product – presumably transferred from the outer packaging. According to Henrik Møller Jensen, this makes it "life-threatening" not to establish systematic self-monitoring and external laboratory testing. At the same time, he expresses an insecurity about the fact, that no laboratories today can test for all PFAS substances and that the definitions are constantly changing.

Need for support and expertise

The company has not sought public funding but believes that subsidies for skills development and access to independent testing capacity could facilitate the process. Smaller companies in particular may find it difficult to understand the chemical, technological, and regulatory aspects. "It all ends up in the PFAS product, which no one fully understands anyway," he says.

Strategic positioning

Despite the barriers, the company has been among the first in its industry to launch a documented PFAS-free product. They now find that this differentiates them positively – especially online, where searches for "PFAS-free" are on the rise. The director expects that in the future it will become a requirement rather than a choice: "It's here to stay. And consumers want it."

Companies that do not know whether they use PFAS

28% of the companies interviewed do not know whether they use PFAS. Of these, as many as 51% say they have not made an active effort to clarify their use of PFAS (see Figure 14). This testifies to widespread uncertainty and a lack of overview in many companies.

35% have contacted suppliers to investigate the matter, fewer (6%) have attempted to clarify it internally through technicians, documentation or audits, and even fewer have attempted to involve external consultants (5%).

The qualitative responses in the other category elaborate on this uncertainty. Several companies express a desire for clarity but do not know how to approach the task. Others describe that they have not looked into whether PFAS are used in the production equipment itself, even though they may not be present in the end product. A few describe that the quantity and type of goods received make it overwhelming to assess, and others expect that the suppliers' official approvals cover the issue.

Some companies note that enquiries to suppliers have not yielded answers because there is a lack of knowledge in the supply chain. This shows that not only the companies themselves, but also their suppliers lack knowledge and documentation.

In other words, there is a significant information gap when it comes to knowledge about PFAS. Many companies have neither an overview of their own use, nor the opportunity to obtain it through their suppliers. There is a need for guidance, standards, and tools to help companies carry out a systematic clarification – especially in cases where the use of PFAS is not obvious.

Besides companies, public purchasers and consumers can prioritize products that are labeled with the Swan label, EU Ecolabel, GOTS or OEKO-TEX. However, not all product groups have a label. The Danish Environmental Protection Agency advises consumers to be particularly vigilant when purchasing outdoor clothing and equipment, cosmetics and impregnating agents.[10]

When companies have not investigated whether they use PFAS – either directly or through their subcontractors – it is primarily due to a perceived lack of relevance (see Figure 15). 49% respond that they do not suspect that PFAS are being used, which may well be the case, and 23% assess that their consumption is too small to be significant.

In addition, a lack of resources and knowledge also plays a role. 17% mention a lack of time or capacity, and 16% say directly that they lack knowledge about chemistry and PFAS. These figures show that many companies, especially smaller ones, do not feel equipped to identify potential PFAS uses themselves, either technically or organizationally.

11% state that it is not a priority for the company, and 9% do not know why no investigations have been carried out. In the other category, it appears that some companies believe they do not use PFAS without having verified this. Several base their assessment on supplier declarations, regulatory approvals or the fact that they do not directly add PFAS in production.

Qualitative responses also indicate that the complexity of the supply chain and the technical invisibility of PFAS create a barrier. Some industries (e.g., the metal and furniture industries) recognize that the substances may be present in small quantities, but without having an overview of the extent. Others refer to the

[10] www.mst.dk/borger/sundhed-og-kemi/pfas-i-forbrugerprodukter

Figure 14. Sources of knowledge about PFAS

Question: Have you attempted to determine whether you use PFAS? Please tick multiple boxes if applicable. Only those who do not know whether they use PFAS. **Source:** Survey, Danish Technological Institute (2025). **Note:** 56 responses – weighted by size and industry.

Figure 15. Why not investigated?

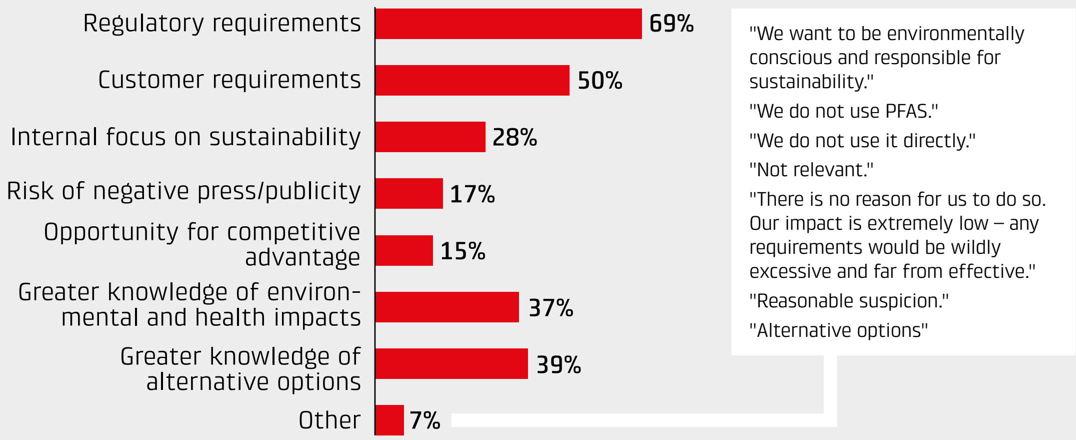
Question: Why have you not investigated whether PFAS is used in your company (or, for example, by subcontractors)? Please tick more than one box if relevant. Only those who do not know whether they use PFAS. **Source:** Survey, Danish Technological Institute (2025). **Note:** 56 responses – weighted by size and industry.

fact that they are bound by standards from manufacturers and authorities. Therefore, they do not have the opportunity to set requirements for substitution themselves.

The lack of action is rarely due to indifference, but rather a combination of perceived low relevance, lack of suspicion, limited knowledge and resources, and dependence on suppliers and standards.

The responses point to a need for increased enlightenment, practical tools, and industry-specific guidelines if companies are to be motivated and enabled to identify and manage their potential use of PFAS.

Figure 16. Motivating factors for companies that have not yet investigated whether they use PFAS



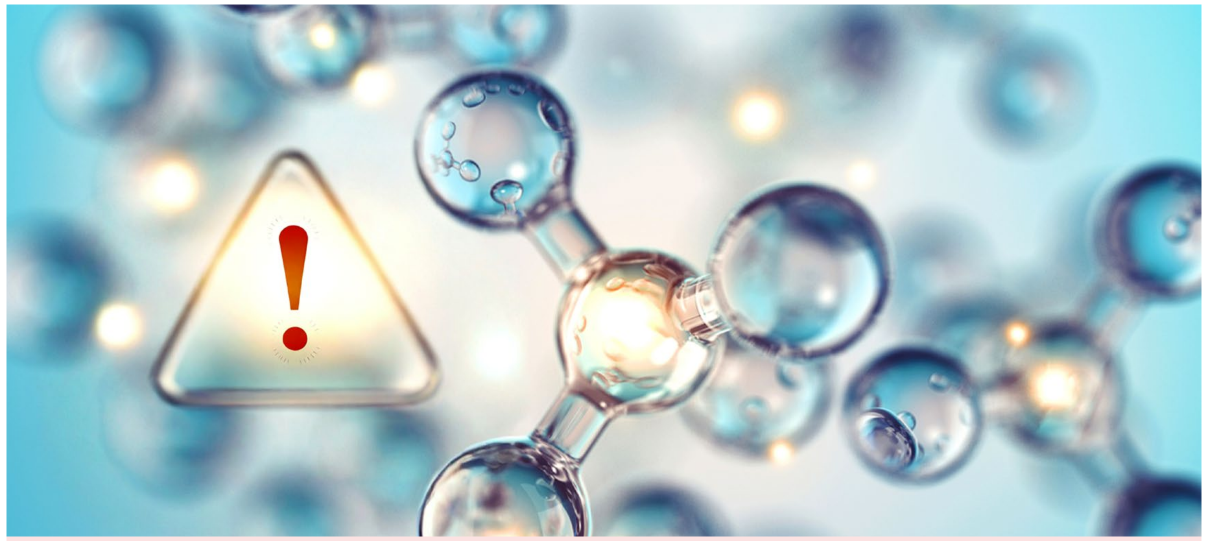
Question: What would make you look into alternatives to PFAS?Please tick more than one box if relevant. Only those who do not know whether they use PFAS. **Source:** Survey, Danish Technological Institute (2025). Note: 56 responses – weighted by size and industry.

Companies largely point to external requirements and incentives as key drivers for initiating an nvestigation into alternatives to PFAS (see Figure 16). The most important factor is legislation: as many as 69% state that requirements from the authorities would motivate them to investigate PFAS substitution. The second most common factor is customer requirements (mentioned by half of the companies), which shows that market demand can play a key role in companies' actions, but as shown above, there is not much demand from the customers.

Internal focus on sustainability is mentioned by 28%, which shows that some companies have their own motivation to act responsibly. However, this is still fewer than those who primarily act on the basis of external requirements. Greater knowledge of alternative solutions (39%) and better insight into environmental and health consequences (37%) are also considered important factors. This emphasizes that a lack of information and overview currently acts as a barrier to action.

Other factors, such as the risk of negative media coverage (17%) and the possibility of competitive advantage (15%), play a more limited role, but may still be relevant in certain industries. For some companies, such as Accoat A/S (see the text box) media coverage can be very important.

The qualitative responses in the "other" category elaborate that some companies already see themselves as environmentally conscious and responsible and therefore want to act regardless of legal requirements. Conversely, several respondents state that they do not use PFAS – or not directly – and therefore do not find it relevant. A few emphasize that their impact is so small that new requirements would be perceived as "overkill".



Public attention closes PFAS company

The Teflon factory Accoat A/S south of Helsingør is an example of how public focus on the use of PFAS can have consequences for the company, which had to close the factory after much media coverage.

The Danish Broadcasting Corporation (DR) reported, among other things, that corrosive fallout from the factory's chimney and "Teflon fever" among employees had been recurring problems for several decades.

DR also reported that the factory was a cause for concern due to possible pollution in the local area, as it is located close to residential areas and a school with an associated nursery and crèche.

The board of directors at Accoat then decided to shut down all activities, citing "public focus" and future regulation of companies' use of PFAS substances as reasons, as well as the fact that the factory was "inappropriately located in the middle of a residential area".

Source: www.dr.dk/nyheder/indland/omstridt-teflonfabrik-lukker

It is also mentioned that a reasonable suspicion that PFAS is actually being used could motivate them to initiate an investigation, which indicates that many are still in a kind of uncertainty zone where action depends on clearer evidence or pressure.

The responses show that regulatory requirements and customer pressure are the strongest levers for getting companies interested in substituting PFAS. In addition, knowledge building and industry information are important supplements if more companies are to be motivated to investigate and implement alternatives – especially in cases where their own use is indirect, unrecognized or considered insignificant.

Global innovation for PFAS-free materials

Danish Technological Institute has mapped research and innovation in alternatives to PFAS, but there are also older technologies that do not necessarily require research and development – e.g. the use of beeswax in clothes to make the fabric water and dirt repellent. We have therefore also included an EU-supported database of substitution options. There are substitution options for many applications, but whether the alternatives are acceptable in terms of functionality, environment, health and economy will require a concrete analysis and assessment by the industrial companies that are faced with making the choice.

Research into alternatives to PFAS

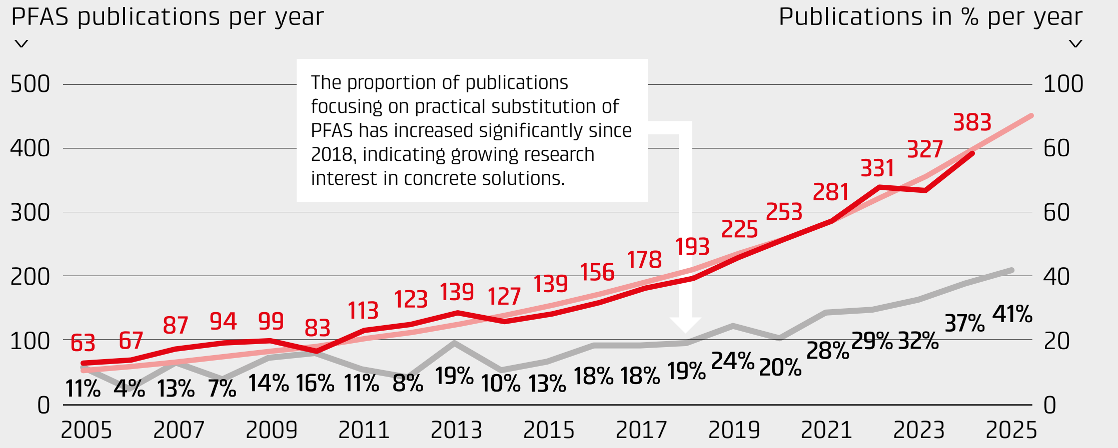
Global research activity in PFAS substitution is growing significantly and has gained momentum, especially since 2018. Scientific interest focuses particularly on applications where the unique properties of PFAS have previously been difficult to replace, including water and oil repellency and chemical resistance. At the same time, new technological processes are paving the way for eliminating the need for PFAS in selected production processes. Denmark is also active in this development, with the Technical University of Denmark (DTU), in particular, making a strong mark in areas such as energy materials and membrane technology.

Research often shows the earliest signs pointing to which technologies and materials are on the rise. When seeking to gain a technological overview of PFAS substitution, it therefore makes sense to start with research. This shows where active work is already underway to find and test alternatives.

Danish Technological Institute has examined international research into how PFAS can be replaced in materials and surface treatments. The focus has been on identifying which functions the research is attempting to replace. We used OpenAlex – an open database of scientific publications – and searched for articles from 2005 to 2025. The search text combined terms such as "PFAS-free", "fluorine-free" and "PFAS replacement" with technical material terms such as "polymer", "membrane", "composite" and "surface treatment". The aim was to find publications dealing with specific technological alternatives to PFAS.

We retrieved metadata for each article and used artificial intelligence (GPT-4 via OpenAI's API) to analyze titles and abstracts. The AI model assessed whether the articles dealt with specific PFAS substitutes and which functional properties were in focus. The results were returned in structured JSON format and linked to the original dataset. The combined dataset gave us an overview of whether the article deals with specific PFAS substitution, as well as which functions the research is attempting to replace in specific application contexts.

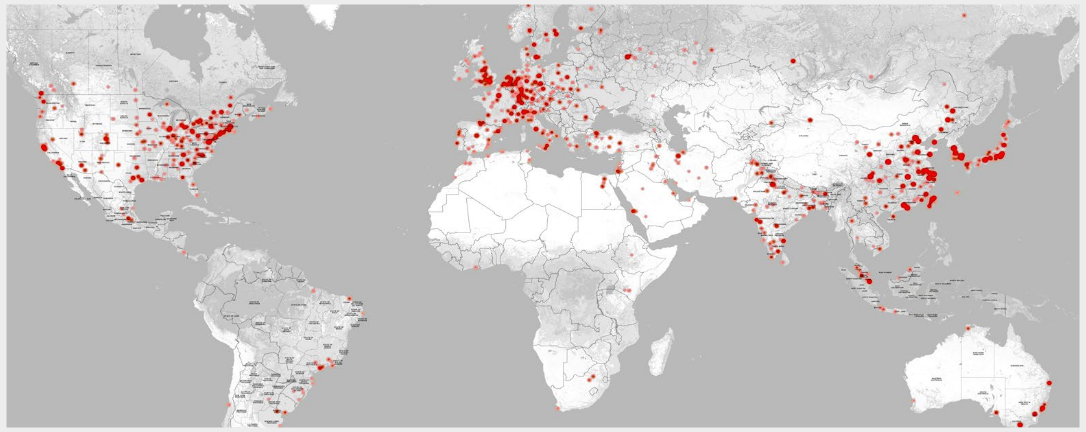
Figure 17. Number of research publications on the topic of PFAS substitution 2005-2025



Development in the number of scientific publications on PFAS substitution, 2005–2025. Data is retrieved from OpenAlex and selected via keywords in title and abstract. The red line shows the total number of publications per year, while the grey line indicates the proportion of these that explicitly deal with the specific substitution of existing PFAS substances. The trend line is exponentially adjusted and highlights the increasing research activity towards 2025. Source: Danish Technological Institute, 2025.

Figure 18. Publications on PFAS substitution worldwide

High concentration Lower concentration



Heat map of innovation activity related to PFAS alternatives based on the geography of the first author and last author in publications from 2005–2025. Data is taken from OpenAlex. The map is not weighted by number of publications per location, but shows overall presence. The interactive version is available at: www.batchgeo.com/map/PFASforskning. **Source:** Danish Technological Institute, 2025.

Development in the scope of research
The number of scientific publications on PFAS substitution has been steadily increasing since the mid-2000s. Particularly after 2015, there has been a significant acceleration from a modest level (see Figure 17).

The pink curve in the figure shows an exponential trend adjustment, highlighting how research activity has accelerated over the past two decades. However, the trend appears to have leveled off somewhat in recent years, which may be due to both market maturation and data limitations. By June 2025, 177 publications on PFAS substitution had already been registered in OpenAlex. Since registrations in the database often lag 6–12 months behind, we consider it likely that over 400 publications will be registered for the whole of 2025. This makes the year the most productive to date in terms of research into PFAS substitution.

While the figure shows the development in the number of scientific publications on PFAS substitution, it also shows the proportion of these that deal directly with the substitution of specific PFAS substances. The grey line shows the proportion of publications with an explicit focus on practical substitution solutions (e.g., development, testing or evaluation of alternatives). From around 2018, there has been a significant increase in this proportion – from less than 20% to over 40% in 2025 – reflecting growing political and research interest in finding specific solutions. This may reflect both increased regulatory pressure and more targeted research funding for substitution-related work.

No single institution dominates research into PFAS substitution. However, several Chinese universities and research centers have published a large proportion of publications related to PFAS substitution in the period 2021–2025. The Chinese Academy of Sciences contributed 34 publications. Donghua University and the University of Chinese Academy of Sciences each account for 23. South China University of Technology has 20.

In Europe, University College London has published 10 publications. The Technical University of Denmark and Technische Universität Dresden have each contributed 9.

Neither the quality of the research, nor the number of citations points to a single leading actor. The most cited articles have been written by many different researchers from different institutions.

This suggests that no one has yet established a firm foothold in the field. At the same time, it shows that the PFAS issue is wide-ranging. PFAS are used in many contexts and therefore require both interdisciplinary knowledge and coordinated efforts across sectors and research environments. It is also an area where solutions are often developed close to practice – for example, in companies' own R&D departments or in sector-linking institutions, such as Research and Technology Organizations (RTO) – which do not necessarily publish in scientific journals.

Focus on functional properties

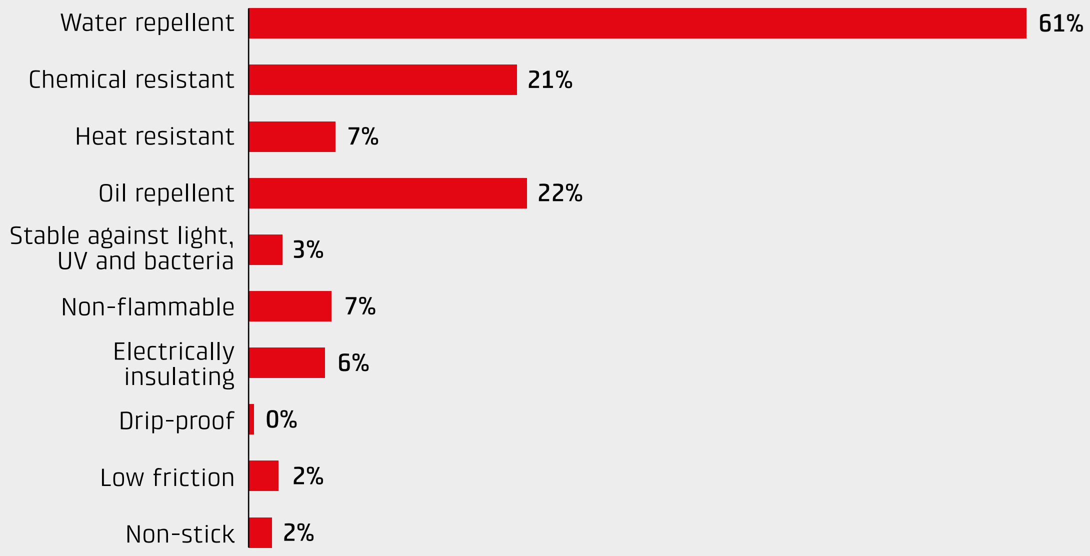
Of the more than 3,000 publications identified on PFAS substitution, 829 deal directly with the development or testing of specific alternatives to PFAS. The remaining publications are also related to the topic but cannot be clearly classified. This is either because the title and abstract are too general or because the content deals with more indirect aspects such as literature reviews, conceptual contributions or theoretical assessments of possible substitutions in specific application contexts.

Figure 19 shows which functional properties the research in these 829 publications attempts to replace.

Around 60% of the publications examine alternatives to PFAS with water-repellent functions. Next, oil-repellent properties and chemical resistance are the most frequently studied.

267 publications deal with the substitution of two or more functions in the same study. These include combinations of water- and oil-repellent properties, chemical resistance, heat resistance,

Figure 19. Functional properties of PFAS alternatives found in research literature



The figure shows which functional properties PFAS substitutions target in 829 scientific publications. The classification was made with AI assistance based on titles and abstracts and subsequently validated by random sampling. Note that 33% of the publications address multiple functions – typically 2, but up to 6 in some cases. **Source:** Danish Technological Institute, 2025.

and flame-retardant properties. These functions often recur in research where they are investigated collectively in different types of materials and applications.

What is being investigated when it comes to alternatives to PFAS?

Research into PFAS substitution has gained momentum in recent years, and a number of studies document specific material solutions that, without any fluorinated substances, mimic — and in some cases surpass — the functional properties for which PFAS has traditionally been used. This applies to water and oil repellency, heat resistance, and surface stability in particular.

A key example is a study by Yang (2025), in which researchers developed a superhydrophobic, fluorine-free coating based on nickel–cobalt phosphate. The coating on aluminum demonstrated both self-cleaning effects and chemical resistance and, according to the authors, points to a real replacement for PFAS in industrial applications (Yang 2025).

Another example from Progress in Organic Coatings (2024) describes a fluorine-free nanocomposite that combines water and oil repellency with flame-retardant properties. According to the authors, it is not merely a substitution, but a functional improvement compared to PFAS-based materials (Ren, et al. 2024).

What these examples have in common is that researchers are not just looking for one-to-one replacements, but are working purposefully to develop safer, more sustainable and functional materials that can match or improve on the uses of PFAS in several areas — without the environmental and health consequences.

However, research into alternatives to PFAS is not limited to the development of new materials and substitutes. A growing body of literature also focuses on alternative production methods and process designs that completely avoid the need for PFAS. Here, it is not a specific chemical structure that replaces PFAS, but rather changes in technology, surface treatment, and production environment that make the use of PFAS redundant.

A notable example is the use of plasma polymerization, where researchers at Fraunhofer IFAM have developed technologies such as PLASLON®, which creates water- and oil-repellent surfaces with high wear resistance and chemical resistance – completely without fluorinated compounds. According to the researchers, this method not only provides the desired functional properties, but also offers advantages such as better adhesion, lower environmental impact and broad industrial applicability (Fraunhofer IFAM 2023, SpecialChem, Researchers develop PFAS-free non-stick plasma coatings for enamel & glass (16 Oct 2023). Available at: SpecialChem Coatings. University of Bristol 2023) .

Researchers from Empa (Switzerland) have also demonstrated atmospheric plasma surface

treatment for textiles, where siloxane-like networks create water-repellent effects without the use of fluorinated substances. The method has been developed for industrial scale and is mentioned in several technical news items and Empa's own channels (Empa / Swiss Federal News 2024, Specialty Fabrics Review 2024, SpecialChem 2024).

These procedural approaches show that the path away from PFAS does not necessarily lie solely in new molecules, but also in the changed ways of designing and manufacturing functional materials. This shifts the focus from substitution to systemic solutions, where entire processes and technologies become PFAS-free.

The Danish contribution

In Denmark, DTU in particular has been active in the substitution of PFAS and related fluorinated substances. The research covers a wide range of areas but has a clear focus on developing new high-performance materials without environmentally harmful substances.

Researchers at DTU are working in particular with superconductors, electrolysis membranes, and organic polymers. The aim is to replace fluorinated substances with safe alternatives, while maintaining the high functionality and stability of the materials.

Jean-Claude Grivel and colleagues have, in a series of studies, demonstrated fluorine-free metal-organic deposition (MOD) fabrication of high-quality $YBa_2Cu_3O_{7-x}$ (YBCO) thin films (Zhao, Chu, et al. 2018) (Zhao, Tang, et al. 2017). In this type of production PFAS has previously been a necessity for good quality thin films.

Yifan Xia and David Aili (DTU) have developed and documented PFAS-free, alkaline ion-solvating polymer membranes for water electrolysis with high chemical/mechanical stability and low H_2 breakthrough, including via macromolecular reinforcement and new poly(oxindole-biphenylene) systems (Xia, Aili og et al. 2024, Xia, Rajappan, et al. 2025) Xia, Aili, et al. 2024, Xia, Rajappan, et al. 2025). Aili et al. also provides a field overview of separators for next-generation alkaline electrolyzers (Aili, et al. 2023).

The DTU environment also contributes to barrier and polymer research related to energy technologies e.g., recent work on water vapor transmission rate (WVTR) in polymeric materials for PV modules (Babin og et al. 2024).

The research covers several technologies but is functionally focused. Particular emphasis is placed on electrical and ionic conductivity, chemical stability and durability in demanding environments. Applications range from superconductors and electrolysis cells to solar cells and material barriers. The common goal is to develop sustainable materials without fluorinated substances without compromising performance.

Innovation and alternatives to PFAS

Compared to other technologies, innovation activity in the field of alternatives to PFAS is relatively low. Danish Technological Institute has trawled through the world's patents to find innovative new technology that can replace PFAS.

Innovation is, among other things, about utilizing knowledge from research activities to develop new methods, processes or products that create value. Patent applications can therefore be used as an indicator of innovation, as they show that a patent authority has assessed an idea or product as something new. At the same time, they signal that a person or company has developed an idea that they have found worth investing time and money into protecting. Although far from all new developments are patented, and patent mapping therefore does not provide a complete picture of innovation, it still constitutes a strong indicator of both technological development and commercial potential.

Danish Technological Institute has conducted a focused patent search in global patent databases with a view to identifying technologies that explicitly offer alternatives to PFAS. The search targets patents describing fluorine-free materials, PFAS substitution or active replacement strategies within relevant material and application areas such as coatings, polymers, barriers, and textile treatments. The search in the patent database is structured based on functions typically associated with the use of PFAS, including properties such as water and oil repellency, chemical resistance, heat resistance, low friction, non-stick and flame retardancy. By combining function words and material or technology types, patents are identified that work with solutions that deliver the same technical properties as PFAS without necessarily being fluorinated.[11]

In total, Danish Technological Institute has identified 2,572 patent families or innovations that have been applied for,[12] which may constitute alternatives to PFAS. The relatively low number of applications and patents illustrates that the technological search is narrow, that technologies that replace PFAS may be traditional and unpatented e.g., beeswax-treated clothes that are both water- and grease-repellent, and perhaps also that there is relatively limited innovation activity. By comparison, the patents on PFAS alternatives are being taken out in all global centers of innovation.

Geographically, the largest players are located in the USA, Asia, and Europe. Together, they cover industries such as electronics, the automotive industry, building materials, energy, textiles, and medical equipment. Common to all these companies is that they have previously been heavily dependent on fluorine-based technologies and are now using their research capacity to develop alternatives, either to comply with regulations or to position themselves in new markets with a higher sustainability profile. Their patent activity reflects both a technological transition and a strategic response to the growing global demand for functional materials without PFAS.

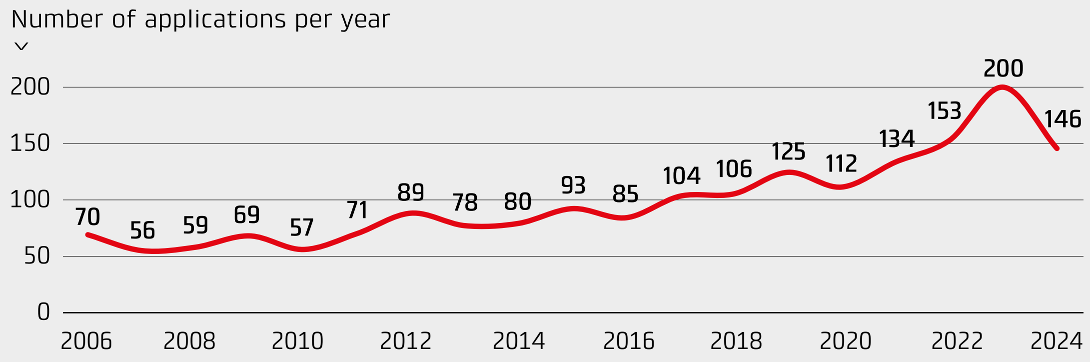
Technological development and innovation in PFAS alternatives are primarily taking place in large international companies. Of the 2,572 patent applications, only one innovation originates from Denmark, placing Denmark at the bottom of the list of countries where relevant patents on PFAS alternatives have been taken out.

[11] To ensure relevance, the search has been further narrowed to include only patents that explicitly or implicitly refer to the technology as an alternative to PFAS. This means that the patent text must contain terms such as "PFAS-free", "fluorine-free", "non-fluorinated", "PFAS replacement" or similar formulations. This ensures that not only the functionality but also the intention of substitution is part of the invention. Thus, the search does not target the entire spectrum of materials with PFAS-like properties, but rather technologies where the desire to avoid PFAS is an explicit part of the solution. Please note that the search does not exclude the possibility that there may be other relevant innovations and that the search does not include an assessment of whether the solutions are technically, environmentally and health-wise better than solutions with PFAS. Please also note that the search includes solutions where the use of PFAS is reduced without being PFAS-free, which is particularly true of older inventions.

[12] Search conducted in mid-March 2025. A patent is granted for a geographical area, and "patent family" is a collective term for all patents relating to the same idea. A total of 11,138 patents have been found, some of which are identical but registered in several countries. The patents have therefore been grouped into "patent families" corresponding to the number of innovations applied for. Typically, just under 7 out of 10 patent applications are approved, but the process typically takes several years from application to approval. The search found 3,013 patents, which were then screened manually and with AI and reduced to 2,572 patents. The development from 2006 to 2023 is shown in Figure 1. This is not a large number of annual patents, but the increasing number of applications – almost double since 2016 – illustrates a growing interest in finding alternatives to PFAS substances.

The Danish contribution is from Fibertex Nonwovens A/S which, in 2025, obtained a patent for a method of manufacturing fluorine-free nonwoven textiles with both water- and oil-repellent properties suitable for use in the automotive industry (e.g., engine insulation, battery covers, headliners). Using a sol-gel-based treatment with SiO_2 particles, a thin, porous layer is formed on the surface of the fibers, which provides water and oil repellency without the use of fluorinated substances. The solution is designed to match

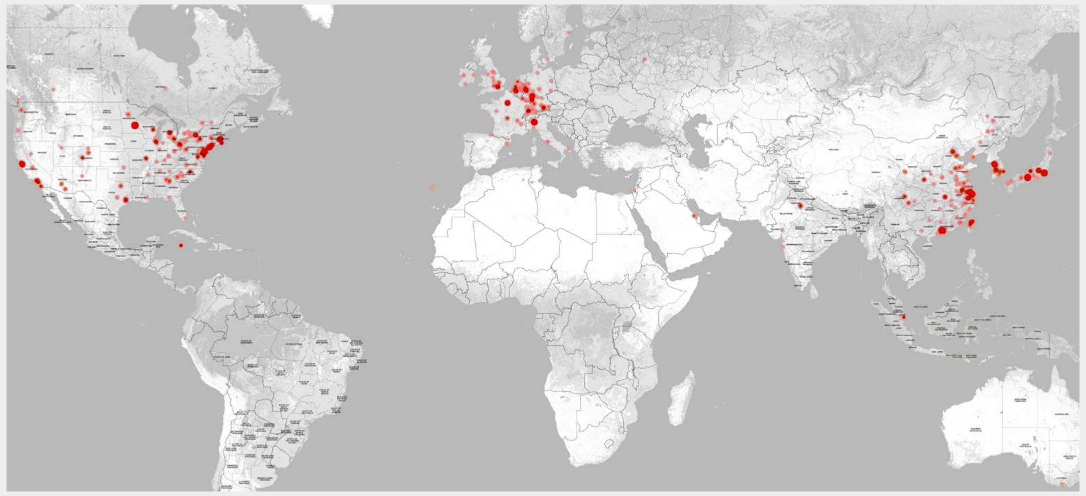
Figure 20. Patent applications 2006-2023



Source: Danish Technological Institute's summary of applications regarding PFAS alternatives. The number of patents in recent years will increase as applications are processed.

Figure 21. Global distribution of patent applications for PFAS alternatives

■ High concentration ■ Lower concentration



Innovation activity for alternatives to PFAS. The map shows the geography of the current patent owner or applicant. **Note:** Patents are weighted by citations. Addresses are not provided for all current owners. The map is available online at www.batchgeo.com/map/PFASPatenter. **Source:** Danish Technological Institute, 2025.

the functionality of fluorinated nonwoven materials, but without the environmental and health disadvantages of PFAS. The invention is a direct fluorine- and PFAS-free alternative to traditional fluorinated nonwovens, and it specifically addresses the challenge of achieving oleophobic and hydrophobic functionality without fluorine.

Among the companies that have taken out the most patents related to alternatives to PFAS are some of the world's largest and most research-intensive chemical companies. These are companies that are either phasing out or divesting PFAS activities, but also companies that have been major suppliers of PFAS-related materials and solutions – and several have paid

Table 2. The 8 most patenting companies in terms of PFAS-free solutions

Company	Patents PFAS-free	PFAS-free alternatives and research focus	Known lawsuits regarding PFAS contamination
3M Innovative Properties Co. (USA)	342	Phasing out PFAS products by 2025. Developing fluorine-free alternatives such as Novec™ materials (3M 2022) .	Several billion-dollar settlements in the US for PFAS contamination (Lerner 2024) .
Daikin Industries Ltd. (Japan)	156	Developing PFAS-reduced solutions and working on PFAS-free alternatives in electronics and heat-resistant applications (Daikin's Approach to PFAS 2024)	Mentioned in connection with environmental concerns, but no major completed lawsuits documented (Perkins 2021) .
Solvay Specialty Polymers Italy S.p.A. inkl. Ausimont	117	Has introduced fluorine-free surfactants and is actively working on fluorine-free coatings and plastic alternatives (Solvay 2021) .	In 2023, paid a large settlement in the US totaling approximately $175 million for PFAS contamination (Solvay 2023)
AGC Inc. (Japan)	53	Working on PFAS substitutes in specialty glass and electronics, but still in the early stages of development.	Mentioned in PFAS-related complaints. (Illinois County Department, Law Division 2023)
DuPont (USA)	45	Developing fluorine-free alternatives to Teflon™ and GenX™ materials.	Major settlements in the past, including one for $671 million for C8/PFOA cases. Most recently involved in several smaller cases (Larsen 2025) .
The Chemours Company FC LLC (USA)	45	Focusing on PFAS-free surfactants for fluoropolymers.	Entered into a billion-dollar settlement together with DuPont regarding PFAS contamination of water supplies in the USA (United Nations 2024) .
Shin Etsu Chemical Co. Ltd. (Japan)	31	Developing silicone-based alternatives as substitutes for PFAS in electronics and optical applications.	No major lawsuits documented.
Arkema Inc. (France)	28	Develops fluorine-free coatings and composite materials for industrial applications.	Mentioned in complaints about PFAS pollution. (Illinois County Department, Law Division 2023)

large compensation for PFAS contamination. These are companies that have opportunities for scaling, experience as solution providers and broad market access. Alternative solutions developed by these companies are solutions that can quickly gain global traction.

The 2,572 applications identified offer solutions that are used instead of PFAS. The most common are alternatives that are water-repellent or heat-resistant. Meanwhile, there is a shortage of solutions that are stable in relation to light, UV and bacteria, as well as chemicals.

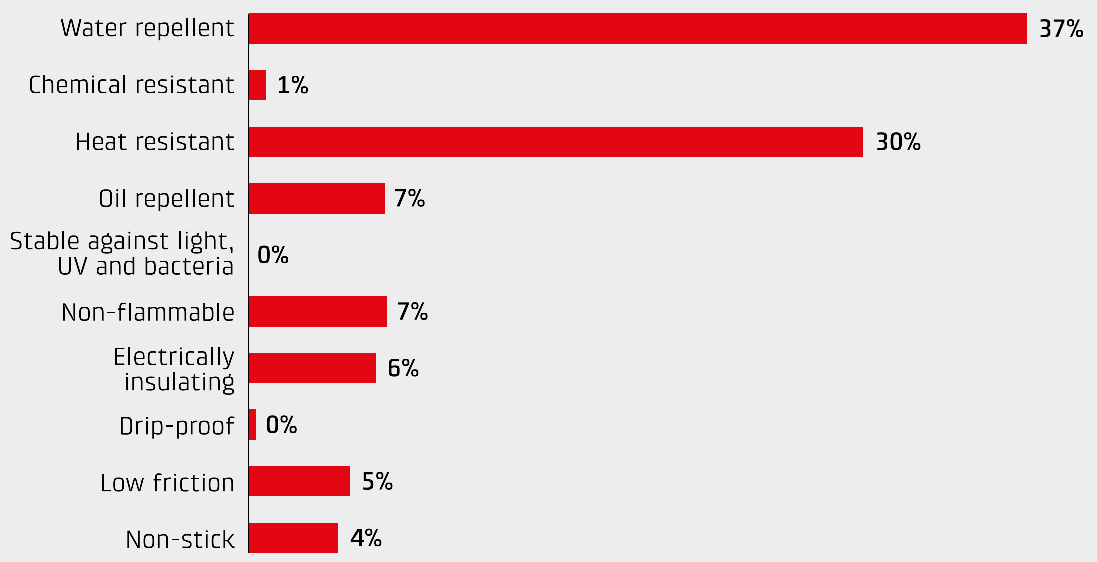
A patent search does not find all solutions, but the sum is an indication of the challenges that industries that have become dependent on PFAS functions for which there are still few substitutes will face.

A review of the 2,572 patents[13] shows that coatings are the most dominant area of innovation, followed by technologies for liquid-repellent fibers and fiber treatment, both of which are highly relevant to the textile industry and technical textiles.

A significant group of patents also relate to known PFAS applications. At the same time, innovations are seen in more specialized applications such as semiconductor production, organic chemistry, and antifouling paints for use in the maritime sector. Finally, data shows that a number of solutions relate to plant-based

[13] The review was conducted by Danish Technological Institute by counting the patents according to "Application Domain", which can be estimated for most patents.

Figure 22. Functional properties of PFAS alternatives found in patent applications



Distribution of 2,572 patent applications by characteristics. Not all could be calculated, and several have more than one characteristic. The review is AI-based and subsequently checked on a random basis. Please note that some innovations cover several functions, while for others this information is not provided or cannot be deduced from the patent.
Source: Danish Technological Institute, 2025.

fibers and metallic surface processes, pointing to a wide range of industrial applications.

In summary, the analysis shows that innovations aimed at replacing PFAS primarily involve developing new materials and processes that can deliver the same functional properties as PFAS – especially water, oil and dirt repellency and chemical resistance – without the environmental and health disadvantages. Efforts are mainly concentrated in the textile sector, surface treatment and specialty chemicals but do extend to electronics and industrial process chemistry.

New alternatives are constantly being found, and the ZeroPM database (see next page, the textbox about ZeroPM's database) as well as ChemSec Marketplace are good sources to stay updated. Articles on possible substitutions are also regularly published in the literature. This applies, for example, to the Royal Society of Chemistry (Balan, Bruton og Hazard 2024, Miljøstyrelsen 2024), which reviews substitution options for a number of industries.

A new study from the European Environment Agency concludes that more and more opportunities for substitution are emerging, motivated in part by increasing regulation. Substitution is likely to be complicated in certain sectors, such as the pharmaceutical sector and sectors working with the green transition, which will require significant research and development efforts. Nevertheless, it also concludes that substitution options exist for the vast majority of applications (Durlin, et al. 2025).

Examples of patented PFAS alternatives

GEOX, an Italian footwear company, applied for a patent in 2024 for a new shoe sole that is both waterproof and breathable without the use of PFAS. The problem with many PFAS-free shoes is that they lose their waterproofing when the membrane in the sole breaks due to repeated bending – especially in the forefoot. GEOX's solution is to incorporate a waterproof membrane into the sole itself and reinforce it with a flexible element that protects the most exposed areas without blocking breathability. This preserves comfort and durability, and the shoe remains waterproof without the use of environmentally harmful fluorinated substances.

Corning applied for a patent in 2023 for a new coating for glass and ceramics that makes surfaces resistant to fingerprints without the use of fluorinated substances. Conventional coatings wear quickly and lose their effectiveness, especially when combined with other treatments such as anti-reflection. Corning has therefore developed a surface treatment that combines a silica-like network with special molecules that make the surface less susceptible to grease and water. The coating is very thin but can withstand extensive wear tests with both cloth and steel wool. It is therefore particularly suitable for products such as smartphones and tablets, where a neat, durable and environmentally friendly surface is desired.

3M Innovation has applied for a patent for a fluorine-free treatment of textiles that is both environmentally friendly and health-safe. The challenge with previous fluorine-free solutions has been that they do not provide lasting oil repellency. The new solution provides water repellency and a certain degree of oil repellency, measured according to AATCC test standards. It can be used on materials such as fabric, leather, synthetic leather, glass, and plastic film, and improves durability and functionality without the use of fluorochemicals. This is a PFAS-free solution that attempts to meet the need for textile treatments without fluorinated substances – with improved, but still limited, oil repellency compared to fluorine-based alternatives.

Perimeter Solutions LP has developed a firefighting foam without fluorinated substances (PFAS). Instead, tiny silica particles are used to stabilize the foam. It is mixed with substances such as glycols, soap-like compounds, biopolymers, and alcohols. The result is a type of foam that retains its shape, tolerates alcohol and solvents, and works in both salt water and dirty water. At the same time, it avoids additives that normally weaken the environmental profile. The foam meets international testing requirements and is particularly suitable for fires involving liquids such as petrol and oil, where it can be used in airports and industrial areas, for example.

Shandong Aosai New Materials Co., Ltd. in China, which solves the problem in pulp production of fluorine-free oil repellents that have poor adhesion to pulp products and provide insufficient oil repellency and heat resistance. The effect also diminishes, over time, during storage. Aosai's solution improves the ability of fluorine-free agents

to bind to paper pulp and provides stable oil repellency – even at high temperatures or when in contact with hot food. It also solves the problem of thermal deformation and improves stability during use (CN119194900B).

Wilana Chemical has developed a new treatment for textiles that makes the fibers resistant to liquids, stains and dirt – completely without fluorinated substances. The technology is particularly aimed at carpets and other textile products where PFAS has traditionally been used, but where these substances are now being phased out due to environmental and health risks. Instead of spray or foam, a method is used where the entire fiber surface is treated under heat. This provides more uniform and effective protection. According to tests, the treatment can provide as good or better liquid and stain repellency than fluorine-based alternatives.

The solution is therefore a sustainable alternative to PFAS in the textile industry and can be used in particular for carpets, furniture, and home textiles where high wear resistance and easy cleaning are required.

ZeroPM's database of alternatives to PFAS

Another source of possible alternatives, besides research articles and patents, is the EU-supported ZeroPM database of alternatives to PFAS (Figuiere, et al. 2024), which is freely available as a beta version.[14] This source does not assess whether the alternatives are better or worse in terms of the environment and health. Only its sufficiency to be an alternative is available. As of June 2025, ZeroPM has reviewed 3,389 uses of PFAS and proposes alternatives to PFAS. The alternatives are listed by chemical name or trade name, for example, and there is likely to be a large overlap with the identified patents, where trade names are typically not disclosed. More than 1,150 alternative materials, products, substances or processes have been proposed. The database is compiled on the basis of a wide range of sources and studies, but the most frequent source is the reports from ECHA – The European Chemicals Agency.

Most alternatives are found in the textile and clothing sector, where alternatives must be able to deliver PFAS-like properties such as water and dirt repellency. Next come applications in pharmaceutical products, lubricants, and agricultural chemicals, where functionality is often critical and alternatives must be carefully evaluated.

The substitution landscape in the ZeroPM database shows that the majority of the proposed solutions for replacing PFAS consist of alternative chemical substances – almost 1,500 registrations fall into this category. This reflects the fact that substitution is often attempted by finding new chemical compounds with similar functionality. Some substitutions, such as beeswax, are well-known alternatives.

Next come alternative materials, such as new polymers or textile surfaces, which can fulfil the functional roles of PFAS without being based on fluorinated chemistry. There are also many alternative products where entire end products have been redesigned without PFAS – for example, impregnating agents or firefighting foams.

In addition, there are a number of alternative processes and technologies that change the way the functions are achieved without necessarily having to replace PFAS with a new chemical. These can be mechanical solutions, changes in production methods or physical treatment of surfaces.

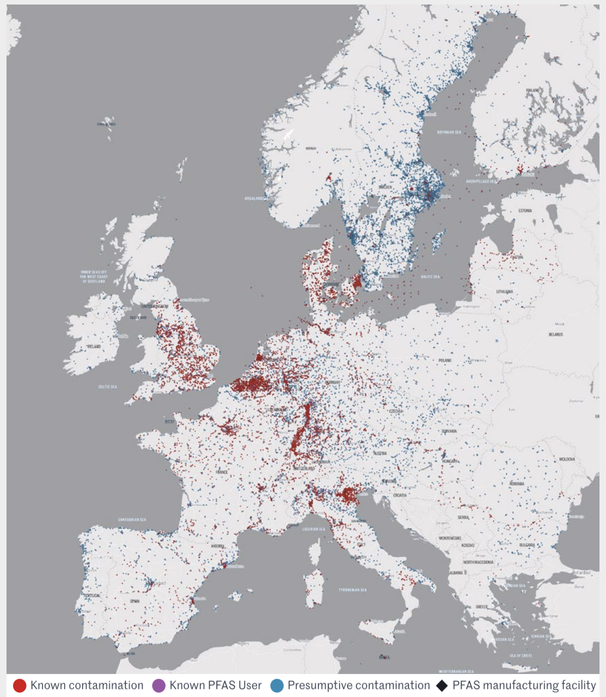
[14] www.zenodo.org/records/10852739

Global market

The market leaders for PFAS production include international chemical companies such as 3M, Chemours, Honeywell, Daikin, Solvay, Merch, Archroma, AGC Inc., BASF, Dongyue, and Arkema. These operate globally. Several of the companies are working on alternatives (see Table 2).

Global consumption of PFAS is significant, but precise figures vary depending on sources and definitions, and there is considerable uncertainty about the number. The background document for the proposal to restrict PFAS, written by, among others, the Danish Environmental Protection Agency, estimates, for example, that in 2020, between 186,000 and 343,000 tonnes of PFAS were used in the EU. According to another recent estimate, around 230,000 tonnes of PFAS are introduced onto the market globally each year, which could accumulate up to 4.4 million tonnes of PFAS in the environment over the next 30 years if it is not regulated (EcoMundo 2023). This figure includes production and use across sectors such as textiles,

Figure 23. PFAS pollution, production and use in Europe



"The Forever Pollution Map" were developed by the newspaper Le Monde in collaboration with partners (journalists and researchers). The map is interactive and shows identified PFAS pollution, PFAS users, and PFAS producers. The map is from 2024 and, according to Le Monde, is based on data from scientific studies and environmental authorities collected between 2003 and 2023. The map can be found at t.ly/SJheg, where all data can be downloaded.

The map covers 23,000 documented contaminated sites and 21,500 sites where contamination is presumed (e.g. landfills, military installations, airports and firefighting areas). In addition, it includes 232 companies that produce paint and varnish, plastics, pesticides, waterproof textiles and other chemicals.

The red spots, which mark confirmed PFAS contamination, show a high density in industrialised areas. The map also provides an overview of where PFAS is measured – and where it is not.

A similar map of PFAS contamination in the United States has been developed by the PFAS Project Lab at Northwestern University and can be viewed her www.pfasproject.com/pfas-sites-and-community-resources

electronics, food packaging, firefighting foam, and many other industrial applications. Textiles account for approximately 35% of the total global demand for PFAS (European Environment Agency 2024).[15]

Despite increasing global regulation and growing documentation of health and environmental damage, the market is expected to grow in a number of high-tech segments. For example, the global market for PFAS chemicals was valued at USD 29.3 billion in 2023 by Statistica and is expected to grow to USD 37.6 billion (Statista 2025).

The PFAS market is affected by opposing forces: continued industrial demand on the one hand and regulatory pressure and insurance requirements on the other (EPA 2025). New documentation for health damage has triggered a rising number of legal proceedings, which has already led to compensation payments of more than 100 billion Danish kroner globally with many new cases on the way in the USA and Europe. As a consequence, insurance companies are now increasing premiums significantly for companies that use PFAS, introducing stricter conditions or just not offering liability coverage. Especially for SMEs, this makes market access, export, and funding more risky.

The risks associated with law and insurance also affect the supply side. Big players, like 3M, have announced that they will stop PFAS production by 2025 at the latest (3M 2022), which adds to the insecurity of supply and prices. The center of gravity in the market is changing from commercial exploitation to risk management and responsibility: Companies must weigh short-term performance gain against the rising costs of compliance, compensation, and insurance. For multiple industries, strategic substitution will not only be a regulatory requirement, but a necessary condition to maintain insurance, customers and access to global markets (See Gaines, 2024; 3M; BloombergNER, 2024).

[15] EECHA, Background Document to the Opinion on the Annex XV dossier proposing restrictions on Per- and polyfluoroalkyl substances (PFASs), Table 3, page 73: Estimated annual quantities from the use phase for PFAS production and the main areas of application in 2020 (low, medium and high estimates). The quantities refer to PFAS used by manufacturers of PFAS-containing products in the sector concerned, as well as to PFAS-containing products placed on the market (as substances on their own, in mixtures or in articles), unless otherwise specified. Average values are used in the impact assessment.

Applications of PFAS in Denmark

Denmark has not actually produced PFAS, but the substances are used in a number of industrial contexts. Point sources of PFAS pollution in Denmark can include fire training grounds, the chrome plating industry, carpets and textiles, paint, chemicals, metal, rubber, plastics, and construction waste landfills, and dumps. Information can be obtained from the DKJord database (Miljøstyrelsen 2025) . In 2024, the newspaper Le Monde published "The Forever Pollution Map", which shows locations with measured PFAS pollution in Europe, including Denmark (see Figure 24).

PFAS contamination in Denmark is typically related to specific uses and has led to documented and suspected "hot spots". Compared to other countries, Denmark has a number of

Figure 24. "The Forever Pollution Map" with ascertained PFAS pollutions in Denmark (2024)

The map zooms in on Denmark and shows both production sites and locations where monitoring has detected PFAS. The observations are grouped if several findings have been recorded at the same location. The observations are included if more than 10 nanograms per litre (ng/L) were observed.

In Denmark, the limit values are 2 ng/L for drinking water, 4.4 ng/L for surface water and 100 ng/L for groundwater (sum of 22 PFAS substances) and 400 ng/L for bathing water (4 PFAS substances) (Danish Environmental Protection Agency, 2025).

"The Forever Pollution Map", developed by the newspaper Le Monde in collaboration with partners. Data is from 2003–2023 and can be found here t.ly/SJheg. According to Le Monde, the data is based on data from scientific studies and environmental authorities.

special conditions. A high proportion of the land area is used for agriculture. We have a long coastline and special geological conditions that affect the mobility of PFAS in soil and groundwater, making it easier for it to reach drinking water. As drinking water in Denmark is based exclusively on groundwater without subsequent chemical treatment, protecting this resource is particularly important.

Waste management is primarily through incineration, while wastewater is cleaned effectively. Increased focus on circularity and green transition will henceforth affect exposure pathways and regulatory needs (Baun, et al. 2023).

In Denmark, the consumption of polymeric PFAS is estimated at approximately 1,690 tonnes per year, a large proportion of which is used in textiles, as well as in food contact materials, packaging, vehicles, and medical equipment (European Environment Agency 2024). There is a clear knowledge gap regarding the total amount of PFAS and the flows of PFAS in Danish society (Baun, et al. 2023) .

The Ministry of Environment and Food mapped industries that use PFAS in 2016 (Miljøstyrelsen 2016), including industrial sectors, and the study covered the years 1983 to 2016 (see Table 3).

The report from the Danish Environmental Protection Agency concluded that, overall, PFAS compounds are used for surface treatment, impregnation, soldering agents, and as additives in paints and varnishes.

Table 3. PFAS uses by industry according to the Danish Environmental Protection Agency (2016)

Industry	Amount reported	Known PFAS compounds	Primary use
Electronics industry	25 tonnes	PFOS, APFO, EtFOSA, MeFOSE etc.	Coatings for cables, soldering agents, surface treatment
Iron and metal industry	20 tonnes	8:2 FTOH, PFOS, APFO, MeFOSE, 6:2 FTSA etc.	Paint, varnish, surface treatment
Chemical industry (including paint)	8,7-19 tonnes	MeFOSE, 6:2 FTSA etc.	Cleaning agents, paint, varnish, impregnating agents
Wood industry	1,2-13 tonnes	MeFOSE etc.	Paint, varnish, printing ink, binders
Paper and graphic industry	12 tonnes	EtFOSA, MeFOSE etc.	Paint, varnish, impregnating agents, binders
Furniture industry and other industries	2,0-6,9 tonnes	Precursorer til PFCA og PFOA etc.	Paints, varnishes, printing inks, rust protection
Machinery industry	0,11-3,2 tonnes	PFOS, MeFOSE etc.	Biocides, paint, varnish, enamels
Rubber and plastics industry	2,0-2,4 tonnes	Potentiel precursor til PFCA	Cables, binders, dyes
Textile, clothing and leather industry	2-2,5 tonnes	8:2 FTOH etc.	Impregnating agents, surface treatment

Excerpt from Table 5.1 of the report: Summary table showing total reported quantities in the years surveyed (1983, 1993, 2003, 2007, 2011, 2013 and 2016) (Miljøstyrelsen 2016). Please note that only industrial sectors are shown. The figures are reproduced to illustrate that PFAS are used in many industries. Please note that the figures are older (2016), so they may have changed since then, and the industry classification is based on an older standard (DB03). The data basis for the survey was primarily the product register.

"Global demand on PFAS-free solutions can give advantages to front-runner companies.

Conclusion and perspective

Danish industrial companies are facing a crucial technological transition as PFAS regulations are tightened in Denmark, the EU, and globally. The EU is working to introduce a comprehensive ban on PFAS, which presents Danish companies with a new reality where substitution is no longer voluntary but necessary. This results in opportunities and challenges that companies should already be actively preparing for.

A significant challenge is that PFAS substances are found in countless products and processes – from electronics and medical equipment to clothing and packaging. Many Danish companies use PFAS, either directly or indirectly via subcontractors, without necessarily being aware of it. The survey shows that almost one in three companies is uncertain about their own use of PFAS, reflecting the high complexity of value chains and a significant lack of transparency regarding materials. This lack of clarity makes it difficult for companies to plan effectively and act proactively. A lack of demand from customers also indicates a more general lack of knowledge or uncertainty about what requirements for PFAS can be imposed on suppliers.

Companies' need for PFAS is typically driven by functionality requirements, such as water and oil repellency, chemical resistance, electrical insulation, and heat resistance. These properties are not easy to replace, and many companies consider the current alternatives to be inadequate in terms of performance, durability, and price. Only when it comes to environmental and health considerations do companies view alternatives positively. This presents a clear challenge: companies must find substitution solutions that not only meet regulatory requirements but also maintain the quality and competitiveness of their products.

A weakness in Danish industry is that substituting PFAS often requires specialized technical knowledge and development resources that smaller companies, in particular, do not have. Many small and medium-sized enterprises lack both materials specialists and experience with chemical substitution. They are therefore dependent on external consultants and suppliers. This dependence can lead to Danish companies responding slowly to new regulations, which could potentially damage their competitive position in both the domestic and export markets.

The threats posed by the upcoming regulation are significant. A PFAS ban could lead to considerable costs, technical difficulties, and delays in production. Companies risk losing orders if they cannot quickly document PFAS-free alternatives. Export-oriented companies, in particular, face a complex regulatory situation with diverse requirements across markets such as the EU, the US, and Asia. This places high demands for documentation and certification, which could potentially hinder exports and increase the administrative burden on companies.

Though, the substitution of PFAS also opens significant opportunities for Danish companies.

Denmark has already introduced early restrictions in certain areas, such as food packaging and textiles, which has created incentives for innovation and the development of PFAS-free alternatives.

The growing global demand for PFAS-free solutions gives Danish companies the opportunity to strengthen their market position. Companies with green profiles that have actively found and documented alternatives can differentiate themselves positively from their competitors. This offers potential for new growth, especially if the company becomes known as a frontrunner in sustainable materials and products.

For Danish companies to take advantage of these opportunities, there is a need for increased access to knowledge and clear technical guidance. Companies are calling for better insight into existing and new PFAS-free technologies. There is a need for easily accessible information on alternatives, testing methods, standards and documentation of properties. This knowledge can be supported through collaboration between industry, knowledge institutions and public authorities.

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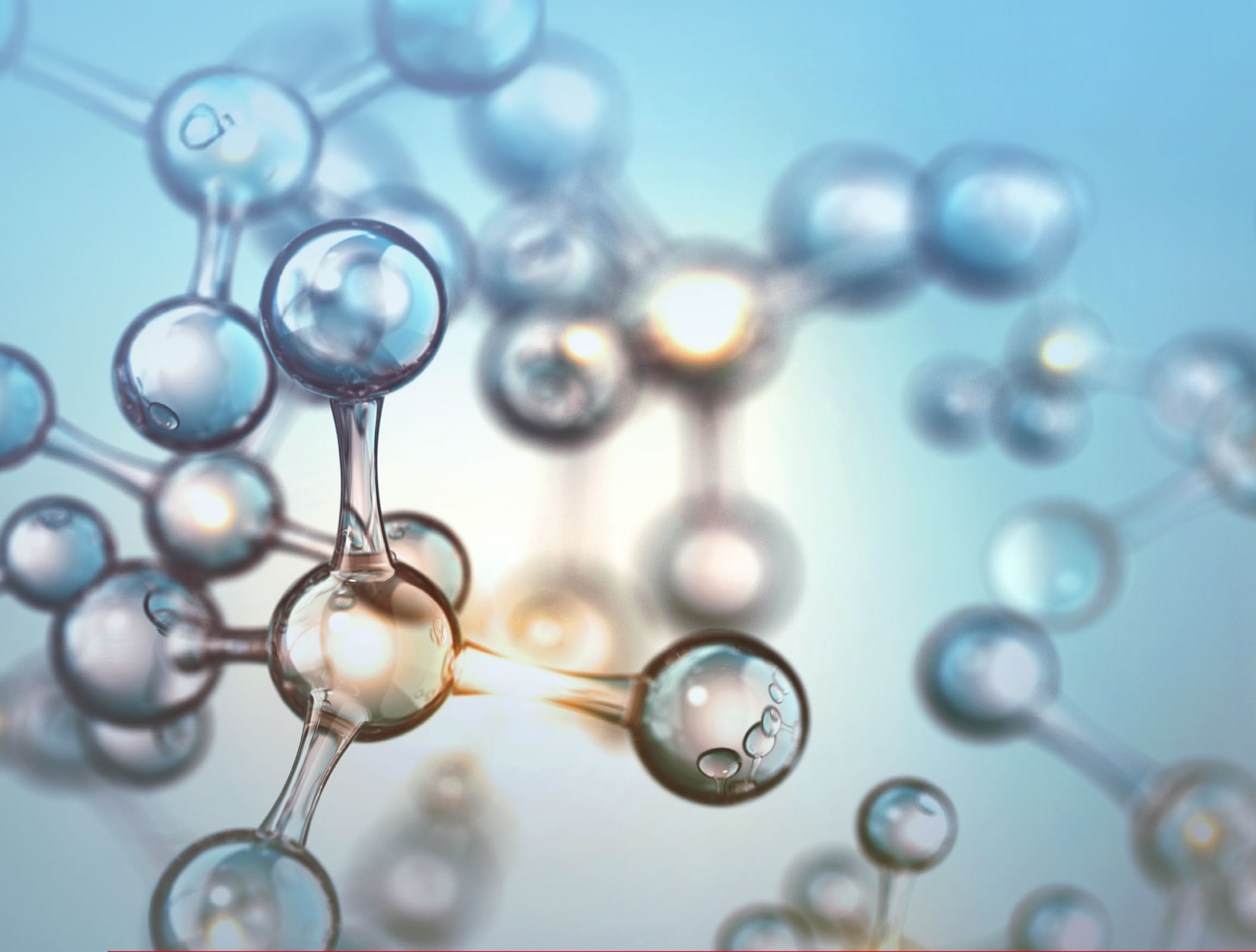

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