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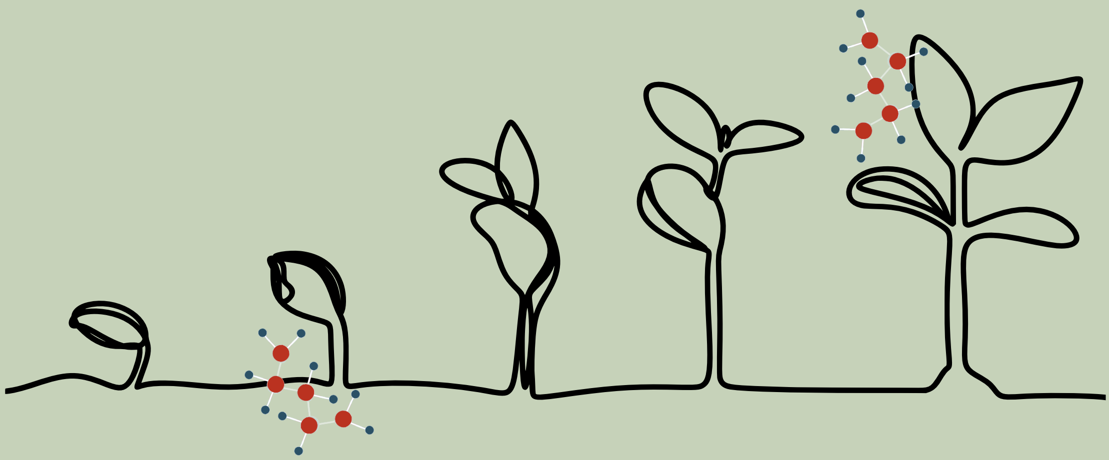
Protecting humans and wildlife from harmful chemicals

Frequently Asked Questions: PFAS and the Green Transition

By CHEM Trust

September, 2025



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1. What are PFAS, and why are they a problem?

Per- and polyfluoroalkyl substances (PFAS), also known as 'forever chemicals', [1] comprise over 10,000 synthetic chemical compounds. The earliest known PFAS compound was first produced in the United States as a fluoropolymer, called polytetrafluoroethylene (PTFE, commonly known as Teflon). Roy J. Plunkett, [2] an American chemist, is credited with the accidental discovery of PTFE in 1938 while employed by DuPont de Nemours, Inc. Since their genesis in the 1930s, PFAS have been incorporated into numerous other industrial and consumer products due to their properties, such as grease, oil, and water repellence, as well as durability. PFAS owe these properties to the presence of the carbon-fluorine (C-F) bond, which is one of the strongest chemical bonds in organic chemistry.

However, due to this extremely strong C-F bond, PFAS take generations to break down. Once released into the environment, they persist in water, polar ice, seafood, vegetables, etc.; removing them is extremely difficult and costly [3]. Many PFAS accumulate in the bodies of living beings who consume the contaminated water and food. A recent study [4] has shown that due to the global spread of PFAS, the irreversibility of PFAS pollution, and the associated biological effects of some PFAS (for example, diseases such as certain types of cancer [5]) a new planetary boundary for PFAS has been exceeded. This means that, in some places, essential environmental resources (drinking water sources, surface waters, and soils) have become irreversibly contaminated with PFAS and threaten the ability of people of this and the next generations to survive and thrive. PFAS can also have an adverse impact on climate change. A study [6] by the United States Environmental Protection Agency shows that the production of PFAS leads to the emission of potent greenhouse gases such as HCFC-22, which is about 5,000 times more potent than carbon dioxide.

According to The Intercept, PFAS manufacturing companies, like Dupont and 3M, [7] knew about the health and environmental risks of PFAS decades ago but did not make the research public [8]. This lag in getting scientific information to regulators has been a factor in prolonged public exposure to PFAS. Scientists have argued [9] that the regulators should learn from this failure and subject PFAS substitutes and other persistent industrial chemicals to prior scrutiny before widespread usage.

2. What is the cost of PFAS pollution?

The cost of PFAS pollution to our society is staggering. From air, water and soil to people's blood and breastmilk, PFAS contamination has become widespread in Europe [10] and is having adverse consequences on people's health across the globe [11]. Chemsec – a Swedish NGO – published a report [12] on the cost of PFAS pollution. The report reveals that the direct healthcare costs from exposure to PFAS in Europe alone are €52-84 billion annually, and the global societal costs may amount to €16 trillion per year. These figures do not include the costs of removing existing PFAS from the environment. If the clean-up costs are involved, the figures will be even higher. For example, earlier this year, a cross-border, interdisciplinary investigation called the 'the Forever Lobbying Project' [13] evaluated the cost to clean-up PFAS emissions in Europe to be up to 2 trillion euros over a 20-year period, with a cost of over €100 billion per year if PFAS emissions are not restricted.

PFAS manufacturing is also becoming financially risky for companies. Recently, an Italian court sentenced the executives [14] at a chemical plant to jail terms of up to 17 years for polluting water used by hundreds of thousands of people with PFAS. PFAS are such problematic chemicals that investors and their representatives with assets worth over $18 trillion under their management or advice have been advising companies [15] to move away from PFAS due to reputational, insurance and liability risks. As shown throughout this FAQ, many companies are already taking heed of this advice and are moving away from using PFAS and investing in PFAS-free technologies instead.

3. How are PFAS currently regulated in the EU?

Currently, seven sub-groups of PFAS [16] are in the process or already regulated in the EU, including those bans that were agreed internationally. Additionally, the EU has also either already finalised or is in the process of finalising the regulation of PFAS in various sectors and environmental media such as: fire-fighting foams [17], children's toys [18], drinking [19], ground and surface water [20], food and food packaging [21]and waste [22].

4. What is the universal PFAS restriction that is being proposed in the EU?

In February 2023, 5 member states (Germany, Sweden, Denmark, Netherlands and Norway) submitted the universal PFAS restriction dossier (uPFAS) to the European Chemicals Agency (ECHA) [23]. The proposal paves the way for a broad ban of PFAS under the European Union's (EU's) chemical regulation - Registration, Evaluation, Authorisation, and restriction of Chemicals (REACH). In August 2025, ECHA published an updated PFAS restriction proposal (the updated version was also submitted by the 5 member states who submitted the original dossier) [24]. The original, 2023, restriction dossier proposed to ban the manufacture, import and use of PFAS, including the intentional use of PFAS in articles. It recommended a ban that would start 18 months after the restriction entered into force (EiF) and certain uses of PFAS, were given derogations of 6.5 and up to 13.5 years (after EiF) depending on how readily alternatives are available on the market. Two time-unlimited derogations were also proposed in the original dossier. Furthermore, biocides, pesticides, pharmaceuticals, and active ingredients in veterinary products were exempt from the scope of the dossier.

The updated dossier adds eight new PFAS use sectors after receiving new information from the industry about these uses during the public consultation process that happened in 2023. Apart from the two restriction options that were proposed in the original dossier, the updated dossier proposes a third option where the manufacture of PFAS in the EU could be allowed, provided emission standards are met, and continued use of PFAS in some sectors could also be permitted by minimising emissions over their whole life cycle. The updated dossier also proposes to increase the number of uses given derogations and the length of derogations for some uses has been proposed to increase to 20+ years. In addition, the dossier proposes that the export of PFAS to non-EEA countries could be continued.

In August 2025, ECHA also published a follow-up statement [25] stating that, to keep its expert committees—the Risk Assessment Committee (RAC) and the Socio-Economic Assessment Committee (SEAC)—on schedule, it would not consider the eight new sectors in its assessment. ECHA has said it will finalise its opinions on the dossier by the end of 2026. After this, the European Commission will draft a definitive proposal for a Member State vote.

5. What are F-gases?

Fluorinated gases, or F-gases, are a type of gaseous PFAS. They are used in various industrial applications such as refrigeration, air conditioning, heat pumps, insulation, fire protection, etc. F-gases are potent greenhouse gases, with some having a global warming potential (GWP) thousands of times higher than that of CO2 [26]. F-gases cause global warming because they trap the heat in the Earth's atmosphere. It should be noted that not all F-gases are PFAS. However, F-gases are responsible for 60% of all PFAS[23] emissions in the EU. Since F-gases have several available alternatives, PFAS emissions from F-gases are easily avoidable. For more information on F-gases, check these FAQs by the European Commission. [27]

6. The EU already regulates F-gases; would it not be a double regulation if F-gases were also included in the u-PFAS restriction?

Some parts of the industry claim that F-gases should not be regulated under the uPFAS restriction because they are already regulated under the EU F-gas regulation [26]. However, the EU F-gas regulation is aimed at only regulating those F-gases that contribute significantly to global warming, like hydrofluorocarbons (HFCs). It does not cover those F-gases which have a low global warming potential, like hydrofluoroolefins (HFOs), most of which are PFAS. Therefore, it is vital to restrict the use of F-gases, such as HFOs, via the uPFAS restriction.

In fact, since the EU F-Gas regulation has restricted HFCs, there has been an increase in the use of HFOs which break down into another PFAS called trifluoroacetate (TFA) [28]. TFA is known for its persistence in the environment. It also moves very quickly through the water cycle (very mobile), and it is impossible to remove it with current technologies in an economically feasible way. Discussions are currently ongoing to classify TFA under the CLP legislation [29] as a persistent, mobile and reprotoxic substance. TFA is found regularly in drinking water as well as in food, and drinks such as juice, tea, beer [30] and wine [31]. More examples can be found in CHEM Trust's TFA FAQs [28]. TFA's increasing concentration in the environment [32] is very concerning as this leads to rising exposure for people and potential impacts on the environment. These serious concerns about TFA are another key reason for ensuring that green transition products are free of PFAS. Overall, the EU F-Gas Regulation and the PFAS restriction proposal are in no way doubling but complementing each other.

7. What are Fluoropolymers?

Fluoropolymers are another category of PFAS, referred to as 'plastic PFAS'. They are used in various industrial sectors, such as aerospace, automotive, medical, etc., because of their properties, such as non-stickiness, low flammability, friction reduction, strong resistance to high temperatures and chemicals, and low flammability. As mentioned earlier, the most commonly known fluoropolymer is PTFE, known by its brand name Teflon, used in non-stick pans and other applications.

8. Why should fluoropolymers be included in the uPFAS restriction?

Some chemical manufacturers are lobbying the EU commission [33] to leave fluoropolymers out of the scope of the uPFAS regulation. Fluoropolymers are often wrongly portrayed by the industry as PFAS which are benign, inert, non-bio accumulative and of low concern. However, independent scientific research [34] shows that fluoropolymers are far more concerning chemicals than the industry is claiming. Below, we debunk some of the common claims made by the industry around fluoropolymers and show why they should remain under the scope of PFAS regulation.

Myth: "Fluoropolymers are polymers of low concern": this is an incorrect argument based on a non-existent definition from the Organisation for Economic Co-operation and Development (OECD). In fact, there have never been any OECD criteria for polymers of low concern to begin with. The OECD has recently clarified [35] that there is no agreement that fluoropolymers are of low concern or that all fluoropolymers meet the criteria. Yet, some parts of the industry have continued to build on this myth and portray fluoropolymers as of 'low concern'.

Myth: Fluoropolymers are inert and non-bioaccumulative and are therefore safe: the main concern with fluoropolymers is not during their use-phase. For instance, if we take the example of a non-stick pan, cooking in the pan might not pose a huge health risk. However, a variety of harmful PFAS will be emitted into the environment when this pan is manufactured and when it reaches the waste stage (i.e., a landfill or an incinerator). The same is true for other fluoropolymer-containing products as well. Studies done across the world have shown that fluoropolymer manufacturing sites are major sources of PFAS pollution (see some examples here from the US [36], China [37], Netherlands [38], France [39]. Because fluoropolymers are extremely persistent under environmental conditions, the disposal of fluoropolymer-containing wastes and products is extremely difficult. For example, when Teflon is incinerated, it can degrade to trifluoromethane [40], which is the most potent greenhouse gas with a Global Warming Potential of 12,400. Landfilling of fluoropolymer [41] containing waste has also been shown to result in emissions of further PFAS which can then leach into surface and groundwater. Studies have also shown that disposing of common fluoropolymers like PCTFE through incineration can generate over 50 harmful PFAS by-products [42]. Therefore, when we think of fluoropolymers, we need to think of the entire life cycle and not just the use-phase. Overall, the science is clear that fluoropolymers are highly problematic PFAS and to ensure effective protection from PFAS pollution, they should come under the remit of the uPFAS restriction.

9. Which green transition sectors are PFAS are being used in?

Fluoropolymers and/or F-gases are used in the following green transition sectors: green hydrogen, heat pumps, solar cells, wind turbines, electric vehicles, and semiconductors. However, as shown in this FAQ, PFAS-free alternatives are already up and coming in all of these sectors and many other sectors. Chemsec, a Swedish NGO, have delivered a series of webinars [43] on PFAS alternatives in some green transition sectors. See also, Chemsec marketplace [44] for more PFAS alternatives in the green sector.

Below, we take a detailed look at various green sectors, their use of Fluoropolymers and F-gases, and the work that is happening to innovate PFAS-free alternatives.

10. Are PFAS necessary to produce green hydrogen?

Green hydrogen is a more sustainable form of energy production because it does not rely on the use of fossil fuels. Instead, green hydrogen technology works by extracting hydrogen from water (by using renewable energy to facilitate this process) and using this hydrogen to generate energy. PFAS like Nafion® (a fluoropolymer) are usually used in ion exchange membranes, which are a component of the technology to produce green hydrogen.

Various companies have taken an innovative approach to creating PFAS-free ion exchange membranes. For example, IONOMR has developed two ion exchange membrane technologies called Pemion™ [45] andAemion+™ [46], which are PFAS-free. Additionally, researchers at Fraunhofer IAP [47] have also developed a PFAS-free alternative called Polyphenylquinoxalines (PPQs). Other companies leading on this innovative work in the green sector are: Cellfion [48], Ionysis [49], Redox.me [50], Hahn Schickard [51],BlueWorld [52], Ecolectro [53], and Imperial [54]. These developments show that non-PFAS alternatives can be found if innovation is supported and encouraged by the proper regulatory framework.

11. Are PFAS necessary in heat pumps?

Heat pumps use refrigerants to transform energy from the surrounding environment into heat. Traditionally, these refrigerants are F-gases. The EU Commission is aiming to speed up deployment of heat pumps from 2025 to meet its climate target and commitments in its REpower EU Plan [55]. It plans to double the annual rate of deployment, rolling out around 6 million new heat pumps each year. As explained in question 6, this transition is leading to an increase in F-gases that are PFAS and breakdown into TFA. It is therefore important to switch to non-fluorinated refrigerants in heat pumps [56].

Various PFAS-free alternatives to F-gases refrigerants are available such as: propane, CO_2, and ammonia (NH_3). The main alternative used in domestic heat pumps is propane (R290), and several manufacturers offer market-ready propane heat pumps [57]. For commercial and industrial pumps, CO_2 and NH_3 are the main alternatives. A recent study [58] also provides a comprehensive list of alternatives to F-gases refrigerants. These natural alternatives are ready for use and have also been proven to be energy efficient[23]. Some critics of F-gas alternatives argue that heat pumps that rely on PFAS-free alternatives, such as propane, present a fire risk. However, there are decades of experience with using propane heat pumps, the risk of flammability is very manageable and propane heat pumps also meet safety certification requirements. Similarly, there are very established safety mechanisms for CO_2 and NH_3 technologies. Scientists advising the industry [59] have pointed out that although managing fire safety for indoor heat pumps can be more complicated than for outdoor heat pumps, it is perfectly possible. They also say that it is important for the whole industry to have clear phase-out dates for F-gases. Overall, F-gases are not needed as refrigerants and natural alternatives are beneficial in several aspects.

12. Are PFAS necessary in solar cells?

A solar cell is a device that converts light energy directly into electricity. PFAS are currently used in the back-sheets of solar cells. Back-sheets are the back layer of a solar panel, the first line of defence for solar cells, and protect the solar panels from harsh environmental conditions. Innovative companies like Endurans solar [60], Solarge [61], Futurasun [62] have created and already marketed several PFAS-free alternatives for solar cell back-sheets. Again, this shows that PFAS are not necessary in all solar energy technology.

13. Are PFAS necessary in wind turbines?

A wind turbine converts wind energy directly into electricity. Fluoropolymers are currently used in paint and coatings for wind turbines to make the blades more durable in harsh weather conditions. Companies like Hempel [63] offer PFAS-free solutions in the wind-sector.

Another application of PFAS in wind turbines is in the switchgear. Switchgear needs an insulation gas to prevent possible fires from electric sparks when switching voltage levels. Currently, sulphur hexafluoride (SF6), the most potent greenhouse gas with a GWP of 25,000 is used. Due to its immense climate impact, it is being restricted in the EU F-gas regulation. New SF6-substitutes are PFAS, however, and are not needed because natural alternatives to SF6 -- insulation gases based on gases of natural origin (namely nitrogen and oxygen) -- are used by several manufacturers in their switchgear. F-gas-free switchgear is widely available from various manufacturers, particularly on medium voltage level [64] [65] [66]. On high voltage levels, F-gas-free switchgear is market-ready. While not all product gaps are yet filled with SF6-free technology, switchgear manufacturers [67] have said that they will be able to produce F-gas-free technologies within the time frames of the EU F-gas regulation.

14. Are PFAS necessary in lithium-ion batteries?

Lithium-ion batteries are rechargeable and are a vital component of electronics such as electric vehicles, smartphones, laptops, watches etc. They have higher energy densities than conventional batteries, so the battery can be smaller but with the same storage capacity. This high energy density is possible because they operate at relatively high voltages. Lithium-ion batteries currently use a fluoropolymer called polyvinylidene fluoride (PVDF) because they need to withstand high voltages. Companies like GRST [68], Leclanché [69], Freyr [70], Tiamat [71], Dragonfly Energy [72], 24 M [73], E-Lyte Innovations and Nanoramic Technologies [74] are doing great innovative work in providing PFAS-free battery solutions.

15. Are PFAS necessary in mobile air conditioning for electric vehicles?

F-gas refrigerants are also used in vehicles for air conditioning systems and in electric vehicles to cool the battery. The F-gas HFO-1234yf is now used in almost all new cars in the EU for this purpose and as with several other F-gases it is a PFAS and pre-curser for (TFA) (see question 6). The availability of alternatives is acknowledged in the uPFAS restriction proposal [23] which concludes that there is “high substitution potential” for electric and hybrid vehicles (pp. 102-103). Volkswagen has already made a commitment [75] to use PFAS free refrigerants for its air conditioning and battery cooling in its battery electric vehicles by 2030. Substitution is more difficult for air conditioning in combustion engine vehicles, but Volkswagen thinks this is possible by 2034. Petrol and diesel cars are in any case being phased out in the EU in order to meet climate targets. Together with the promising developments with PFAS-free alternatives in Li-batteries (see question 15), the transition to PFAS-free electric vehicles is underway.

16. Are PFAS necessary in semiconductors?

Semiconductors have many different uses. In the green transition sector, they are used in electric car engines and for converting wind and solar energy into electricity in wind turbines and solar cells, respectively.

Currently, fluoropolymers and short-chain PFAS are used to produce semiconductor elements for various technical uses. However, the search for PFAS-free alternatives is happening in the semiconductor sector and has already brought some good results. For example, various PFAS-free alternatives are available for the etching process in the semiconductor sector. For example, a report by ChemSec [76] shows that PFAS etchants can be replaced by buffered oxide etchants, chrome etchants, and tetramethyl ammonium hydroxide etchants. Another study [77] has found four more PFAS-free etchants: BG10, CG50, Brij35, and BrijS100. These alternatives are functional and successfully implemented. Toxicity comparisons also indicate that these alternatives are far less hazardous to human health than PFAS.

17. Are any other companies moving away from PFAS in their businesses and supply chains?

Many companies are making a dedicated effort to move away from PFAS in products and supply chains, demonstrating that a PFAS-free economy is possible. These companies belong to wide-ranging sectors such as cosmetics, clothing, grocery stores, home appliance retailers, etc. You can find more information on these companies on ChemSec's 'No PFAS corporate movement' [78].

18. Are PFAS emissions on an upward trend?

Based on the assumptions regarding PFAS usage trends, a more than 1000% increase in PFAS emissions from 2025 to 2050 just for the electronic and semi-conductor sector is predicted (see Annex E, section E.2.11. of the uPFAS restriction proposal [23]). The use of PFAS F-gases (see question 6) is also leading to an increase in TFA (see question 7). One study [79] predicts a 250-fold increase in TFA due to the transition from the F-gas HFC-134a to its replacement HFO-1234yf. However, as this briefing shows, alternatives do exist making this rise in TFA avoidable.

19. Why should future green transition technologies be PFAS-free?

There is strong evidence that industry will find solutions for alternative products and processes without impacting on the essential needs of society. PFAS-free alternatives are either already available or are up and coming in all the green transition technologies for which the industry claims PFAS are necessary. A transition contributing to the already existing PFAS crisis cannot be called a green transition. Even if further releases of PFAS were to be immediately prevented, PFAS that already exist in the environment will continue to be a source of toxic exposure for future generations due to their extreme persistence and toxic properties. As we have highlighted in this FAQ, the costs of PFAS pollution are extremely high; it is, therefore, in the EU's own interests to regulate PFAS as broadly and strictly as possible. PFAS regulation will not only protect our planet from the adverse impacts of these persistent pollutants but will also create incentives to research PFAS-free alternatives and, in turn, will encourage the kind of innovation and business competitiveness that the EU leaders [80] have been calling for.

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