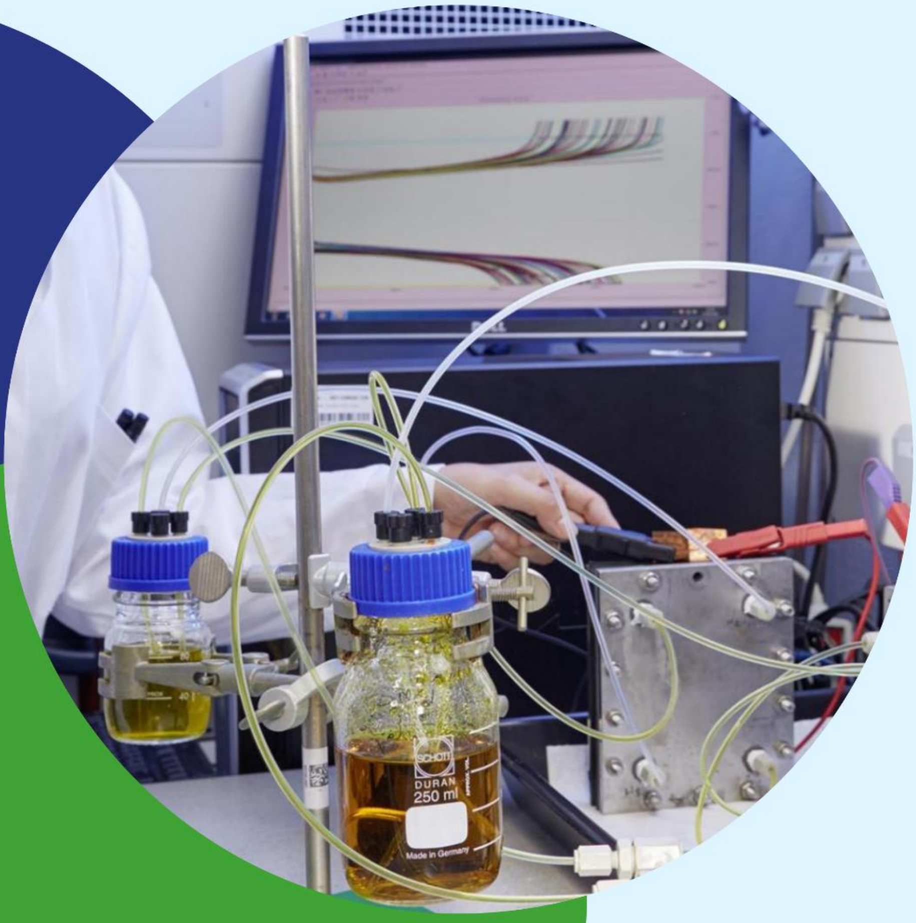
FLOW BATTERIES EUROPE

A united voice for flow batteries

PER- AND POLY-FLUOROALKYL SUBSTANCES (PFAS) RESTRICTION PROPOSAL

POSITION PAPER



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Per- and poly-fluoroalkyl substances (PFAS) restriction proposal

Flow Batteries Europe Position Paper – September 2023

1. Introduction

The proposed restriction of per- and poly-fluoroalkyl substances (PFAS) by the European Chemicals Agency (ECHA) is intended to prevent the use of these synthetic chemicals in Europe due to concerns over their health and environmental impacts. The ban was proposed by the ECHA on February 7th, 2023, following a request from five national authorities (Germany, Denmark, the Netherlands, Norway and Sweden) back in 2021. This prohibition at the European level has been justified by the desire to avoid the substitution of one PFAS for another one. **Flow Batteries Europe (FBE) appreciates the chance to offer feedback on the proposal for the restriction and supports the stated objective to replace the use of fluorinated polymer processing aids, *where possible*.**

Fluoropolymers, considered as PFASs, are notably present in certain flow batteries' ionomer and ion exchange membranes. They are also used in several other components of a flow battery stack, as well as being widely used in accompanying subsystems including power electronics, pumps, seals and gaskets. It is important to consider the impact of a ban on the development of flow batteries for Europe's industry and energy security. **Our paper details the role of PFASs in the production of flow battery technologies and demonstrates why careful consideration is required in the wording of any restriction for the sector during the implementation of the PFAS restriction.**

Key messages:

- Flow batteries utilise fluoropolymers which are **not classified as hazardous** under the EU Classification, Labelling and Packaging Regulation. Fluoropolymers ensure the stability and safety of flow batteries, that are crucial for the technology performance and durability.

- **It is crucial to distinguish fluoropolymers** from other PFASs compounds, **recognising them as non-toxic and essential chemicals for the energy transition.** It's important to acknowledge that not all PFAS chemicals are harmful, and non-hazardous ones should not face limitations in their applications.

- Flow Battery Europe recommends **exempting fluoropolymers from the restriction**. Additionally, to ensure a level playing field concerning the use of fluoropolymers, all energy storage technologies should be treated equally when it comes to exemptions.

- If the exemption of fluoropolymers cannot be achieved, a **derogation period of 13.5 years** would be vital for the flow battery sector, allowing the research, development and long-term testing of alternatives.

- Flow battery companies, universities, and R&D centres are actively exploring alternative solutions. For instance, **certain organic flow batteries use entirely PFAS-free membranes**. However, market-ready flow battery technologies rely on components with fluoropolymers.

- **The outright and immediate ban on fluoropolymers would have a significant socio-economic impact** on the EU and would cause innovative technology companies to leave the European market or shift focus from flow battery technology. **Without technological advancement, the EU's ambitious climate goals will not be achieved.**

- In case the restriction scope does not change, the **EU should prioritise the allocation of sufficient funding towards the R&D** of PFAS-free flow batteries and the sustainability and risk profile of current technologies.

2. The role of flow batteries

Flow batteries are energy storage systems particularly well-suited for long-duration energy storage (LDES; over 4 hours) through the storage of liquid electrolyte solutions in external reservoirs. This configuration allows flow batteries to charge and discharge over long periods of time, with certain models exceeding 20 000 cycles and 20 years, notably zinc/bromide and vanadium flow batteries. They can cycle and recharge throughout this period with almost no loss in power. Another significant advantage of flow batteries is their low flammability, as the key component of the non-flammable electrolyte is water. **Their longevity and the safety brought by their liquid electrolytes make flow batteries increasingly popular for electricity storage**, particularly as the development of renewable energy intensifies in Europe.

One of the main distinctions between different flow battery technologies is the type of electrolyte being used to store energy. The dozens of available electrolyte variants can be classified into two main categories, metal-based and organic. The metal-based category has achieved the highest level of advancement in the market. Among metal-based flow batteries, extensively studied chemistries encompass iron/chromium, zinc/iron, and zinc/bromide. It is important to highlight that vanadium flow batteries have emerged as the most prominently developed choice within the energy market.

The progress of organic flow batteries is also unfolding. New chemistries are being discovered and early results are very promising. Research shows that organic flow batteries can be produced with non-corrosive and readily available material, such as iron sulphates, lignin or bio-polymers. These minimise environmental impacts and safely enable large-scale deployment.

Although most organic flow batteries use completely PFAS-free membranes, market available flow battery models do rely on fluoropolymers that are crucial for the technology performance and durability. **The EU cannot afford to slow down the deployment of available flow batteries by introducing an immediate and outright ban on PFAS.**

3. The use of PFAS in flow batteries

PFASs are a large class of synthetic chemicals that contain carbon-fluorine bonds, one of the strongest chemical bonds in organic chemistry. They are sometimes identified as 'forever chemicals' as they resist degradation when used or entering the environment. The proposed definition of PFASs from the ECHA includes about 10,000 substances with different economic uses and environmental impacts – any substance that contains at least one fully fluorinated methyl (CF_3) or methylene (CF_2) carbon molecule, without any H/C1/Br/I attached to it. This description should be improved by better classifying all considered chemicals according to precise risk categories. The current broad scope fails to capture the socioeconomic impacts of the listed PFASs as well as their actual risk levels.

Our research amongst members of FBE and other organisations in the flow battery community indicates that **all PFASs contained in flow batteries are part of the fluoropolymers category**. Fluoropolymers are polymers made of fluorocarbons that have several carbon-fluorine connections and they should be distinguished from other PFASs due to their specific chemical properties and low environmental impact. These substances are considered to be non-hazardous and they are not classified as dangerous by the EU Classification, Labelling and Packaging (CLP) Regulation. As non-mobile molecules, fluoropolymers do not risk being circulated widely into the environment and their high molecular weight means that they will not be absorbed into the bloodstream.

Due to their durability under extreme conditions as well as their electrical and thermal insulation, fluoropolymers can be found in most types of flow batteries, depending on the particular electrochemistry and the manufacturer. Their major use is in the cell membranes and the jointing materials to hold the membrane to the stack frame. The following PFASs can be found in flow batteries:

- **Polyvinylidene fluoride** (PVDF): stable material used for the pump-magnetic coating and sensor connection because of its acid and oxidation-resistant properties
- **Fluoroelastomer** (FKM, FPM): rubber employed for gaskets with resistance to high temperatures for thermal stability
- **Polytetrafluoroethylene** (PTFE): strong resin used in gaskets to preserve the chemical of membranes
- **Perfluorosulfonic acid** (PFSA): used in combination with PTFE to reinforce the membrane

These substances can be identified in membranes, pumps, sealings, and hoses. Fluoropolymers ensure the stability and safety of flow batteries, notably by preventing leaks and ensuring their thermal stability. These aspects are particularly important for the reliability and sustainability of a LDES technology such as flow batteries, and therefore also essential for the EU's energy transition.

4. Estimation of tonnages of fluoropolymers present in flow batteries

According to FBE internal consolidated data, approximately 1 m^2 of a membrane is produced per 1 kW of a flow battery. 1 m^2 of membrane contains around 20-40g PFSA ionomer and 1-5g ePTFE reinforcement by weight. This means that a 10MW flow battery would contain around 10,000 m^2 of membrane, 30kg of PFSA and 3kg ePTFE. In 1 GW (1,000 MW) of flow battery capacity, there would be approximately 3,000 kg (3 t) of PFSA and 300 kg (0,3 t) of ePTFE. Based on our assessments, approximately 100 MW of flow batteries are presently in operation across Europe, including the UK, which means around 300 kg of PFSA and 30 kg ePTFE are currently present in the European market.

The European Association for the Storage of Energy (EASE) estimates that 200 GW of energy storage must be deployed regionally by 2030 to meet the EU Green Deal's ambitious renewable energy targets. Approximately half of this target should be LDES – 100 GW. Flow batteries represent around 3-5% of the LDES market today. Therefore, the estimated installation of flow batteries in Europe by 2030 could be between 3 GW and 5 GW, depending on their market share growth and technology adoption over the next few years.

Consequently, if 3 GW of flow batteries are installed by 2030, the estimated tonnages of fluoropolymers used in membranes on the European market will be 9 tons. **It's important to note that, even with the support of the EU, achieving these energy storage goals remains highly ambitious.**

5. Estimation of potential emissions

Based on the information provided by the manufacturers of membranes (which is not limited to flow batteries but also includes the whole production of fuel cells and energy products), we estimate that the potential emitted materials are as follows:

- Manufacture < 1,5% (and 3% in waste)
- Service life < 0,1% (as PTFE does not outgas, erode or degrade during service life)
- End-of-life < 1% emissions

Components containing PFAS are used within closed systems, preventing the substances from escaping into the environment. In the end-of-life phase, flow battery components will be recycled, ensuring that the recycling company manages the PFAS-containing substances responsibly to prevent any release into the environment.

6. PFAS alternatives for flow batteries

There is currently a lack of alternatives to fluoropolymers for market-ready flow batteries. Flow battery companies, universities and R&D centres are actively looking into alternative solutions. As an example, organic flow batteries are PFAS-free. However, the most durable flow batteries currently available rely on parts with fluoropolymers (membranes, sealings, gaskets, and others). Effectively replacing fluoropolymers will require large investments that will not be possible in-house for many manufacturers and will fall onto suppliers. An outright and immediate PFAS restriction is thus likely to reduce the price competitiveness of flow battery manufacturers and their suppliers. In particular, we point out that vanadium flow battery, which is currently the most commercialised technology, is relying on parts with PFASs. Batteries developed without fluoropolymers are generally less stable and durable.

To develop alternatives to the flow battery technology relying on fluoropolymers, time and support would be necessary, nonetheless industry is not able to answer if a successful transition is possible. Flow batteries are known for their extended operational life, with some models surpassing 20 000 cycles and lasting up to 20 years. However, when utilising partially developed or tested membranes with alternative elastomeric sealings, the corrosion stability becomes limited. As a result, the durability of flow batteries is at risk.

While certain substitutes for PFASs are under investigation, their effectiveness relies on the specific technical requirements of battery models and their membrane needs. For instance, ion-selective membranes offer an example where fluoropolymers may not be necessary to separate monovalent anions and cations. One promising alternative to the membranes used in organic flow batteries is sulfonated poly aryl ether ketone (SPAEK); nevertheless, these membranes are relatively new, and efforts to gather long-term test data are still ongoing. It is also known that these membranes are not compatible with vanadium flow batteries due to their incompatibility with vanadium oxide.

FBE recommends exempting fluoropolymers from the restriction of per- and poly-fluoroalkyl substances, considering that they are not environmentally harmful and non-toxic, and that they play a critical role in energy storage technologies, as well as in the deployment of renewable energy. Additionally, to assure a level playing field concerning the use of fluoropolymers, all energy storage technologies should be treated equally when it comes to exemptions (i.e., lithium-ion, the hydrogen sector including electrolysers and fuel cells, and flow batteries).

If fluoropolymers are not excluded from the ban, flow battery sector requires the 13.5 years derogation period, to allow the research, development and long-term testing of alternatives. Concurrently, we emphasise that the EU would need to prioritise the allocation of sufficient funding towards the R&D of PFAS-free flow batteries and the sustainability and risk profile of current technologies.

7. Socio-economic impacts

FBE has identified significant socio-economic impacts caused by the potential ban on PFASs. One major repercussion would be the increased operational expenditure, as replacing PFAS-based sealings with alternative solutions is expected to incur additional costs, estimated to be in the range of at least 10%. These higher expenses could potentially trickle down to consumers, affecting energy storage system prices and overall market competitiveness. Moreover, the chemical industry and laboratory sectors, which are vital players in the production of flow battery components, would be directly impacted by the ban, leading to potential job losses and economic strain. **The outright and immediate ban on fluoropolymers would have a significant socio-economic impact on the EU and would cause innovative technology companies to leave the European market or shift focus from flow battery technology.**

The implications of such a ban extend beyond financial considerations. Flow batteries play a pivotal role in facilitating the smooth and rapid green transition towards renewable energy integration. As a LDES technology, flow batteries help to overcome the intermittent nature of renewable energy sources, providing a stable and reliable power supply during periods of low generation. **A ban on fluoropolymer-containing parts could threaten the production and widespread adoption of competitive technology, hindering the seamless incorporation of renewable energy into the grid.** This, in turn, may delay the achievement of the EU's climate goals and its transition to a sustainable energy future, as it may be challenging to efficiently store excess renewable energy without robust and long-lasting capabilities.

As we pursue an environmentally conscious path, it becomes imperative to carefully balance the environmental concerns associated with PFAS chemicals while considering the potential socio-economic repercussions of a ban.

8. Conclusion

FBE call on the ECHA to exempt fluoropolymers from the upcoming PFAS restriction considering that they are non-hazardous and non-toxic. The importance of fluoropolymers to the green transition and the energy security of Europe further justifies this distinction from other PFASs.

We stress that flow batteries represent an essential storage solution that is particularly sustainable due to their durability and safety. Their contribution to the REPowerEU and Green Deal objectives, notably through supporting the deployment of renewables, could be hampered by an inadequately implemented PFAS restriction. **Therefore, if fluoropolymers are not excluded from the ban, FBE advocates for a 13.5 years derogation period for the flow battery industry, enabling a sustainable, long-term stability tests-based and economically viable transition.** The objective is to ensure that no solution is excessively rushed without adequate safeguards and to maintain the durability of flow battery technologies.

Finally, more funds should be allocated to the development and deployment of PFAS-free flow batteries in Europe. **It is not clear what efficiency flow batteries can achieve without PFASs and further efforts are needed, in line with the carbon footprint and performance provisions from the recent EU Batteries Regulation.**

ABOUT FLOW BATTERIES EUROPE

Flow Batteries Europe (FBE) represents flow battery stakeholders with a united voice to shape a long-term strategy for the flow battery sector. We aim to provide help to shape the legal framework for flow batteries at the EU level, contribute to the EU decision-making process as well as help to define R&D priorities. FBE is working to create and reinforce networks between key stakeholders in the flow battery industry.

FOR FURTHER INFORMATION

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