

PFAS RESTRICTION UNDER REACH REGULATION (EC) 1907/2006: WHY EXEMPTING HFO-1234YF & HFO-1336MZZ F-GASES FROM UPCOMING RESTRICTION IS VITAL FOR THE EU 'GREEN DEAL' AGENDA DISCUSSION PAPER (JUNE 2022)

Context

Per- and polyfluoroalkyl substances (PFAS) are a large group of chemicals with widely different physical, chemical, and biological properties. The general category PFAS is not based on the physiochemical or biological properties of the substances. Their only common denominator is that they include at least 1 perfluorinated methyl (-CF₃-) or methylene (-CF₂-) group. They all contain carbon-fluorine bonds, which are one of the strongest chemical bonds in organic chemistry.

As part of the 'Green Deal', the June 2019 Environment Council Conclusions "Towards a Sustainable Chemicals Policy Strategy of the Union", and the European Chemical Strategy for Sustainability (October 2020), the EU has taken a political course to **eliminate all non-essential uses of PFAS** in accordance with the Annex XVII restriction procedure set out in Regulation (EU) 1907/2006 (REACH) due to their persistency in the environment. Within this context, on 15 July 2020 five EEA Member States (DE-NL-DK-SE-NO) **submitted to ECHA an intention to initiate an Annex XVII restriction process under Regulation (EU) 1907/2006 (REACH) to restrict the manufacture, placing on the market and use of PFAS.**

Two calls of evidence ran between 11 May 2020 – 31 July 2020 and 19 July 2021 – 17 October 2021 respectively. These were complemented by a Regulatory Management Option (RMO) Analysis (June 2021) where the five countries reiterated that "a restriction is the most effective and efficient way to manage such a large and complex group of substances that are used in numerous applications" to avoid a "regrettable substitution of restricted PFAS by other PFAS". The five countries are in the process of reviewing inputs from data calls to eventually narrow down the scope of the restriction.

Facing a six-month delay, the final dossier is expected to be submitted by January 2023.

The restriction process is expected **to run until 2024-2025** and will be concluded with a decision on the Annex XVII inclusion taken by the European Commission assisted by the REACH Committee.

One group of substances targeted by this restriction proposal is a **group of fluorinated gases (hereinafter 'F-gases')**: hydrofluorocarbons (HFCs) and hydrofluoroolefins (HFOs). Four are of

particular importance for the refrigeration, air-conditioning, heat-pump and foam industry: **HFO-1234yf¹**, **HFO-1336mzzZ²**, **HFO-1336mzzE³** and **HFC-32 (also known as R-32)⁴**. **HFC-32** is likely to be out of scope of the process (non-PFAS chemical composition *strictu sensu*).

The three other F-Gases, however, fulfil the OECD 2021 PFAS Definition. Further, these F-Gases **degrade into trifluoroacetic acid, TFA (CAS 76-05-1)**, if unintentionally released into the atmosphere: HFO-1234yf fully degrades into TFA⁵, and HFO-1336mzz has a very low TFA-yield (max theoretical yield < 4 %⁶). TFA is a naturally occurring substance, but it may have anthropogenic sources as well, including, among others, the breakdown of some HFCs or some HFOs in the atmosphere.

A potential restriction would derail key EU strategic objectives as it fails to take a holistic perspective on the contribution of the F-gases to the European Climate Policy & European economy.

The present paper is a thought-starter for policymakers, providing a high-level overview of the market of F-gases, key issues around TFA and how Chemours – together with its value chain partners – proposes to address these responsibly outside of the REACH Regulation. As explained further in the paper, the REACH Regulation and the restriction process foreseen under REACH is not an appropriate Regulatory Management Option (RMO) for these types of products, as this approach risks defeating the scope of key socio-economic environmental European initiatives.

HFO-1234yf & HFO-1336mzz: Background, Identity, Key applications & Benefits

Background

F-Gases are specialty performance refrigerants and fluids. They offer three main properties: *cooling, heating and insulation (blowing agents)*. They are essentially applied in several sectors: air-conditioning and refrigeration (mobile and stationary), heat-pumps, as well as foam-blowing agents, followed by propellants and solvents (and others, to a lesser extent). Latest generation substances, in addition to having ultra-low global warming potential (GWP) – historically the key driver behind innovation – also meet high performance requirements.

¹ 2,3,3,3-tetrafluoropropene (EC 468-710-7, CAS 754-12-1)

² cis-1,1,1,4,4,4-hexafluoro-2-butene (EC 700-651-7, CAS 692-49-9)

³ (2E)-1,1,1,4,4,4-hexafluoro-2-butene (EC 811-213-0, CAS 66711-86-2)

⁴ HFC-32 Methylene Fluoride, difluoromethane (EC 200-839-4, CA 75-10-5)

⁵ EFCTC website – <https://www.fluorocarbons.org/environment/environmental-impact/tfa-as-an-atmospheric-breakdown-product/>, retrieved on 1 June 2022

⁶ *Idem*.

Whilst fulfilling a vital societal function, **F-Gases have been increasingly regulated** at international (Montreal Protocol⁷) and EU levels (F-Gas Regulation⁸, MAC Directive⁹). F-Gases of the first and second generation were particularly regulated due to their high ozone-depleting and global warming (GWP) potentials. The recent decade has seen a progressive shift to the *fourth generation (HFOs)* of F-gases, which are enabling the industry to progressively transition to low- and even very low GWP solutions in a nondisruptive manner.

It is for that reason that, except from some niche applications (e.g., medical inhalers), F-Gases are intentionally designed to be handled and operated in closed, secure systems, recovered and re-used.

As for **blowing agents**, industry members are actively planning further measures to improve recovery of building materials. In fact, art. 8 point 4 of the new Commission Proposal for a new F-Gas Regulation unveiled in April 2022 requires that, as from 1 January 2024, building owners and contractors remove metal-faced panels that contain foams with fluorinated greenhouse gases during renovation, refurbishing or demolition activities by qualified persons.

Evolution

The current generation of F-Gases is the result of Industries efforts to find F-Gases with more favourable hazard profile. E.g., the first-generation **CFCs**¹⁰ – largely responsible for the initial depletion of the ozone layer – were first substituted by HCFCs¹¹, which have a lower ozone-depleting potential. With increased understanding, they have been progressively replaced beginning in the 1990s by the third generation of F-Gases, **HFCs**¹² such as HFC-134a. Since 2006¹³, HFCs have also been under stricter pressure giving way to a fourth generation **HFOs (=uHFC)**¹⁴ with even shorter atmospheric lifetimes and ultra-low GWP, such as HFO-1234yf and HFO-1336mzz-isomers.

Current importance of specific HFOs

Modern air-conditioning systems are reliant on fourth-generation refrigerants to such an extent that, as of today, nearly every single new vehicle placed on European roads, certain stationary refrigeration units and heat pump systems contain HFO-1234yf as the backbone refrigerant. As the decarbonization

⁷ An international treaty designed to protect the ozone layer by phasing out the production of numerous substances that are responsible for ozone depletion, entering into force in 1989 and undergoing nine revisions, including the latest one in 2016 (Kigali)

⁸ Regulation (EU) No 517/2014 of the European Parliament and of the Council of 16 April 2014 on fluorinated greenhouse gases and repealing Regulation (EC) No 842/2006

⁹ Directive 2006/40/EC of the European Parliament and of the Council of 17 May 2006 relating to emissions from air conditioning systems in motor vehicles and amending Council Directive 70/156/EEC

¹⁰ **Halogenated** chlorofluorocarbons (CFCs)

¹¹ **Hydrochlorofluorocarbons** (HCFCs)

¹² **Hydrofluorocarbons** (HFCs)

¹³ With the entering into force of Directive 2006/40/EC (MAC Directive) and Regulation 842/2006 (F-Gas).

¹⁴ **Unsaturated** HFCs (u-HFCs) or **hydrofluoroolefins** (HFOs)

of our society and transport sector progresses, ultra low GWP F-Gases will become more important to climate goals

HFC-32 is also expected to be the key co-formulant in nearly every HFO-1234yf-containing blend in the years ahead, due to more demanding energy efficiency and temperature requirements for cooling devices placed on electric vehicles (EV) and other applications.

HFOs are expected to save by 2025 hundreds of million tons of CO₂e¹⁵.

In conclusion, HFO-1234yf is the backbone component in RACHP systems, while HFO-1336mzz-isomers are mainly used as blowing agents for the foam industry these days and in some blends for RACHP applications.

Innovation, alternatives & trade-offs

R&D on the fifth-generation low GWP alternatives (including HFO-1234yf) is ongoing, but it is at a nascent stage. Typically, based on previous industry track record in innovation, **it takes 10-15 years to invent, test, manufacture & commercialize new molecules**. In addition, the **R&D process must strike a delicate trade-off** between a set of a few distinct performance requirements demanded by the market, some being at times mutually exclusive:

- ✓ No ODP and very low GWP (recently the key driver behind innovation).
- ✓ Safety requirements: low or non-flammability & low toxicity.
- ✓ Increasing energy and resource efficiency requirements of RACHP (refrigeration, air conditioning, heat pumps) equipment.
- ✓ competitive total cost of ownership (TCO).
- ✓ Safe to handle, especially for SMEs.

Alternatives to F-Gases exist. Yet these alternatives have major drawbacks as compared to HFO-1234yf, HFO-1336mzz and HFO/ HFC-blends (e.g., R-454C). For example, **carbon dioxide, is contained at very high pressure and has lower energy efficiency depending on store equipment architecture and ambient conditions¹⁶**, **ammonia** is toxic for humans and environment, **propane and other hydrocarbons** are highly flammable. The trade-off needed to offset these limitations are additional complexity, less resource-efficient equipment and/or lower reliability. The final decision on which substance is best suited for the task is highly situational and depends on the use-case.

¹⁵ Chemours Expects Opteon™ Portfolio to Reduce Greenhouse Gas by 325 Million Tons by 2025

<https://www.chemours.com/en/news-media-center/all-news/press-releases/2016/chemours-expects-opteon-portfolio-to-reduce-greenhouse-gas-by-325-million-tons-by-2025>, retrieved on 1 June 2022

¹⁶ REDUCE EMISSION BY SELECTING LOW GWP HFO REFRIGERANTS LIKE OPTeon™ XL

<https://www.opteon.com/en/support/resource-center/opteon-wave-emissions>, retrieved on 1 June 2022

In contrast, HFO-1234yf, HFO-1336mzz and HFO-1234yf/HFC-blends are some of few refrigerants/blowing agents meeting the above requirements. Furthermore, **they are *not* persistent in the air compartment (their atmospheric lifetimes are 12, 27 & 122 days respectively).**¹⁷

Chemours is one of the major suppliers of the three substances in Europe. Other REACH registrants/producers of HFO-1234yf include Honeywell and other companies. Chemours is the only REACH registrant and supplier of HFO-1336mzzZ and HFO-1336mzzE in Europe.

No F-Gases – No ‘Green Deal’

At the end of 2020, the new von der Leyen Commission launched the **flagship ‘Green Deal’ initiative**, accompanied by an ambitious package of sub-initiatives and legislative proposals. One of the major pillars is to reinforce EU climatic conditions over a period running from 2030 to 2050, reiterating Europe’s commitment to become ‘carbon neutral’ by 2050, but also fostering transition towards more sustainable and durable mobility.

No ‘green transition’ is however possible in Europe without the most advanced classes of F-gases. F-gases, and particularly the most advanced fourth generation HFOs, such as 1234yf and 1336mzz-isomers, fulfil a vital role in the EU ‘Green deal’ ecosystem:

- ✓ Reducing direct CO₂ emissions.
- ✓ Enabling household and industrial equipment to meet highest energy efficiency objectives.
- ✓ Reducing energy consumption via better insulation.
- ✓ Extending products equipment lifetime.
- ✓ Improving resource efficiency requirements.
- ✓ Facilitating in achieving the deadlines set out in the ‘Green Deal’.

In addition, to the above, the three F-gases do not have a significant human health & environment toxicity profile, offer a more favourable safety profile to downstream users, and allow a favourable total cost of ownership (TCO) vs. alternative solutions.

How are F-Gases’ emissions & recovery regulated?

Three major pieces of International and European Law regulate the placing on the market, use and disposal of F-gases in Europe and, so far, particular focus has been placed on third generation HFCs:

- 1) Montreal Protocol (Kigali Amendment, 2019).
- 2) F-Gas Regulation (EU) 517/2014.
- 3) Mobile air-conditioning systems (MAC) Directive (EU) 2006/40.

The **Kigali Amendment** foresees to reduce the use of HFCs (related to their climate impact) by more than 80 % in the next 30 years and sets out an HFC phasedown with regional variations that reduces HFC consumption by 85% in CO₂ tons equivalent.

¹⁷ Atmospheric lifetime for 1234yf is 12 days, 27 days for HFO-1336mzzZ and 122 days for HFO-1336mzzE.

The objective of the EU **F-Gas Regulation proposal** is to reduce F-gases emissions for at least 55% by 2030 and climate neutrality by 2050¹⁸. This reduction is achieved by several means, including:

- **Prohibitions on use and placing on the market**, insofar as technically feasible and more climate friendly alternatives are available.
- **Continuation and expansion of the scope of regulations** concerning containment, leak tests, certification, disposal, and labelling.
- **Stronger enforcement:** enhanced coordination across EU Member States including penalties for non-compliance.

In that respect, the **F-Gas Regulation** provides a comprehensive **legal & technical toolbox to control emissions**, which includes leak checks, leakage detection systems, recovery, producer responsibility schemes, training and certification, restrictions on the placing on the market, labelling, control of use etc.

In April 2022, the Commission has presented a proposal to review the 2014 F-Gas regulation, which includes new additional measures on **containment and recovery for all gases, including HFOs (see chapter on the “Way forward” at the end of the document)**.

The MAC Directive implements a similar mechanism, yet with a focus on air conditioning systems placed on vehicles. More specifically, the MAC Directive bans the emissions of F-gases from certain mobile air conditioning systems in passenger cars (vehicles of category M1) and light commercial vehicles (category N1, class 1). This is to be achieved by a gradual ban on the use of F-gases with a GWP higher than 150 in mobile air conditioning systems. Although the MAC Directive does not provide for leak checks and recovery on refrigerants with GWP lower than 150, it is worth noting that:

- Under the MAC Directive, service providers must be trained experts, offering service and repair for air-conditioning systems cannot fill such equipment with fluorinated greenhouse gases if an abnormal amount of the refrigerant **has leaked** from the system, until the necessary repair has been completed; and
- Under the F-gas Regulation, F-gases removed from all mobile air-conditioning systems during maintenance and dismantling of the vehicle must be **recovered** by appropriately qualified personnel, to ensure their recycling or destruction.

It can be concluded that the F-gas Regulation and the MAC Directive are complementary to each other and ensure an appropriate system of F-gas recovery. In addition, the 2000/53/EC directive on end of life of vehicles mandates that all end-of life vehicles are stored according to the Waste Framework Directive 75/442/EEC. This includes treatment operations for depollution of end-of-life vehicles such as the removal of batteries and liquified gas tanks.

When introducing restrictive measures against HFCs, the above pieces of International and EU law pay particular attention to the compounds’ **global warming potential (GWP)**. However, emissions

¹⁸ *IMPACT ASSESSMENT REPORT Accompanying the document Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on fluorinated greenhouse gases, amending Directive (EU) 2019/1937 and repealing Regulation (EU) No 517/2014, SWD(2022) 96 final.*

control requirements foreseen by these pieces of law are also pertinent to some of the HFOs, even if the main concern around them is degradation into other natural occurring substances. **By reducing emission of F-gases in the air, degradation products will also be reduced.**

Potential Future Degradation to Trifluoroacetic acid (TFA)

TFA: natural emissions into the ocean

Trifluoroacetic acid (TFA) is a naturally occurring acid of which 95% is coming from natural geological and 5% comes from anthropogenic sources¹⁹. The main source of natural TFA is hydrothermal vents. Due to its high mobility, it is found mostly in marine environments as a salt. Natural presence of TFA in global oceans is estimated to be at the level of 200 million tons^{20&21}.

TFA is highly persistent, degrading for decades from the environment.

As TFA concentrations have been increasing in terminal sinks in Europe (varying depending on the region), and as it can be produced by the **breakdown** of some HFCs/HFOs in the atmosphere, recent years have seen TFA falling under increasing scientific scrutiny.

Nevertheless, the human and environmental health effects of TFA have been thoroughly evaluated in various toxicology studies listed in the TFA REACH registration dossier. TFA is not classified as hazardous to human health after long-term exposure. Environmental effects occur only at concentrations which cannot realistically be reached²².

In addition, the UNEP Environmental Assessment Panel reviewed studies of serum samples from hundreds of participants living close to a chemical plant manufacturing fluorinated chemicals (first ever measure of TFA in the blood of humans in relation to environmental exposure). Seeing low levels of TFA in the bloodstream (median concentration of 8.46 µg/l²³ vs. No-observed-effect-concentration (NOEC) for aquatic species typically > 10.000 µg/l), it explicitly concluded that *"risks from current and future releases of TFA from the use of fluorinated precursors regulated under the Montreal Protocol to aquatic and terrestrial plants are de minimis"*.¹⁹

In other words, based on the current state of knowledge, it is therefore clear that TFA presents no risk to humans and the environment, whilst current and estimated concentrations of TFA in the environment are not expected to exceed toxicity (NOEC) levels.

¹⁹ EFCTC Special Review: Understanding TFA," European Fluorocarbons Technical Committee, 2016

²⁰ Scott B.F., et al., "Haloacetic Acids in the Freshwater and Marine Environment," First International Symposium on Atmospheric Reactive Substances, 14-16 April 1999, Bayreuth, Germany.

²¹ Von Sydow L., et al., "Natural background levels of trifluoroacetate in rain and snow," Environmental Science & Technology, 34, 3115-3118, 2000.

²² Liji M. David et al. Trifluoroacetic acid deposition from emissions of HFO-1234yf in India, China, and the Middle East

²³ Y. Duan, et al. Environment International 134 (2020)

TFA anthropogenic emissions: F-gases, pesticides & pharma

Several studies, including UNEP (2016²⁴) and UBA (2021²⁵), scrutinized anthropogenic emissions, yielding somehow conflicting results:

- UNEP estimates that only a small fraction (<5 %) of TFA found in oceans originates from anthropogenic sources. It is believed that TFAs on land have been transported by the mechanical action of wind on the sea, just like sea salt aerosol.
- UBA, however, argues that nearly all TFA found in surface and drinking waters (15.000 tons/year in EU-27, set to increase to 50.000 tons/year by 2050) is of anthropogenic origin, and is the reason why immediate actions vis-à-vis halogenated compounds are required. This is, however, contested by many involved stakeholders **emphasizing that UBA projections are four times too high.** This is in line with data reviewed by Chemours which indicate that instead of the UBA figures of 37.000t/a in 2030, the more likely range is around 8.000t/a²⁶. This contrast can be explained through their usage of older references (2002) and therefore too high leakage rates over the lifetime. The technology has improved significantly over the last 20 years. This results in lower charge sizes, lower leak and higher recovery rates.

TFA accumulates mainly in terminal water bodies such as marine waters, and in the estuaries of larger rivers^{27&28}.

F-Gases are by design circular and can be recycled and re-used. However, UBA assumes in their modelling approach an unrealistic worst-case scenario, which neglects recycling and

²⁴ Solomon K, Velders G, Wilson S, Madronich S, Longstreth J, Aucamp P, Bornman J. 2016. Sources, fates, toxicity, and risks of trifluoroacetic acid and its salts: Relevance to substances regulated under the Montreal and Kyoto protocols. *Journal of Toxicology and Environmental Health B*. This report is an Accepted Manuscript of an article published by Taylor & Francis in *J Toxicol Environ Hlth B* on June 27, 2016, available online: <http://www.tandfonline.com/10.1080/10937404.2016.1175981>

²⁵ Behringer et al. Persistent degradation products of halogenated refrigerants and blowing agents in the environment: type, environmental concentrations, and fate with particular regard to new halogenated substitutes with low global warming potential. Umweltbundesamt, 2021.

²⁶ REACH registration dossier under review at the time of writing the present paper.

²⁷ Umweltbundesamt, Chemikalieneintrag in Gewässer vermindern, Trifluoracetat (TFA) als persistente und mobile Substanz mit vielen Quellen. Quellen, Eintragspfade, Umweltkonzentrationen von TFA und regulatorische Ansätze, November 2021.

²⁸ UBA further identified three sources of emissions for Germany:

- 1) Degradation product of certain F-gases. Among the HFO refrigerants the degradation to TFA differs by substances and ranges from 0 to 4% in the case of 1336mzz-isomers to up to 100% in the case of 1234yf. UBA (2021) made the speculative assumption that by 2050, 1234yf will be the refrigerant with the highest demand and emissions, arguing there would be an issue.
- 2) Pesticidal actives substances metabolite, the biggest contributors being flufenacet (197 tons/year), diflufenican (84 tons/year) and fluazinam (78 tons/year).
- 3) Pharmaceutical substance. TFA on its own is used as a drug due to its therapeutic properties. But the contribution of pharmaceuticals to the global pool of TFA is unknown.

re-use. This is not just unrealistic but also disregards the effectiveness of the F-Gas regulation in mitigating unintended emissions.

TFA emissions from F-Gases.

It should also be stressed that TFA emissions during the production of parent compounds is negligible. Marginal emissions are possible during the operation of a vehicle (e.g., 10 g/year/car²⁹), and refill of air conditioning and refrigeration equipment. End of life emissions of TFA are likely possible during product application but also when demolishing buildings containing 1336mzz, degrading up to 4% into TFA.

However, there is a continuous economic rationale to avoid emissions of 1234yf. **F-gases are relatively too costly** to let them 'simply evaporate'. This is the reason why emissions' recovery is consistently improved: not only because it is legally required, but also because it is economically justified.

In conclusion, F-gas emissions are being addressed by stronger containment measures (such as leakage prevention, leakage detection, training and certification programs at installers and end-of-life disposal measures) included in the F-Gas regulation proposal issued by the European Commission.

Why do F-Gases *not* meet REACH restriction criteria?

REACH foresees restrictive measures (e.g., SVHC List, Annex XIV inclusion) for **several broad groups of hazard classes**: CMR substances, PBTs, and vPvB. It must be stressed that no other intrinsic property (e.g., persistence alone or very persistent and very mobile – vPvM) are eligible for certain restrictive measures under REACH, unless it is demonstrated that they are of equivalent concern to CMRs, PBTs, and vPvB substances.

Next to SVHC listing and authorisation, the REACH Regulation also foresees restriction of substances, provided that certain conditions are met.

Article 68(1) of REACH states that a substance can be restricted "when there is an **unacceptable risk to human health or the environment**, arising from the manufacture, use or placing on the market of substances" (emphasis added).

Although not explicitly indicated, it is clear from the spirit of the article that judging the merits of "**unacceptable risk**" hinges upon the fulfilment of two criteria: a substance's ***intrinsic properties***

²⁹ The Mobile Air Conditioning emission per year should be 3,006 MT/year due to a lower refrigerant leakage rate. Calculation is based on amounts of PFAS in HVACR-systems (ca. 0.6 kg/personal vehicle, ca. 1 kg/unit per truck and ca. 6 kg/unit per bus) and taking into account the total number of registered passenger cars (242,727,242), trucks (sum of light and heavy commercial vehicles: 34,340,233) and busses (692,207) in the EU (ACEA 2019) it can be assumed that a total amount of approx. 180,000 t of F-gases are used in HVAC-systems for passenger comfort in road traffic in EEA. Based on an average leakage of 10g/vehicle per year (see David Sousa – Pastel 2009) with a charge size of 0.6kg, this equates to a leakage rate of 1.67%. 180,000 MT x 1.67% = 3,006 MT emissions in EEA per year. Source (page 21, paragraph 1.3 System and components emissions level): <https://bit.ly/TSSRef31> <https://bit.ly/TSSRef32>

(hazards) coupled with **exposure**. In other words, no risk is possible in the absence of exposure to hazardous substances and, vice-versa, when there is exposure, but a substance is not hazardous

It must be stressed that certain **intrinsic properties** (e.g. persistence alone or substances that are very persistent and very mobile – vPvM) are not eligible for restrictive measures under REACH, at this point in time, unless there is conclusive evidence that (a) such other intrinsic properties trigger an 'equivalent level of concern' under Article 57(f) of REACH or (b) pose an unacceptable risk that needs to be addressed at EU level, as foreseen in Article 68(1) of REACH.

In other terms, a substance that is persistent alone is not *per se* eligible for restrictive measures. To be subject to risk management measures under REACH, this substance shall also trigger an equivalent of concern as per Article 57(f) of REACH or pose an unacceptable risk that needs to be addressed at EU level. The equivalent level of concern is measured in comparison to the criteria related to substances listed in points (a) to (e) of Article 57 REACH and which are identified on a case-by-case basis.

Neither 1234yf nor 1336mzz-isomers are classified as toxic to human health (including persistency), so they do not meet any hazard criteria today and do not pose any 'unacceptable risk' to human health and within the legal meaning of REACH.

In addition, REACH does not cover **degradation products**. Manufacture, use and placing on the EU market of parent's compounds cannot be banned solely based on a mere presence of a degradation product in the environment.

Finally, although no legally binding definition of "**essential use**" exists at EU level, HFO-1234yf and HFO-1336mzz isomers explicitly fulfil the Montreal protocol definition due to their vital role in achieving EU climate objectives in the absence of technical and economically feasible (fifth generation) alternatives.

In other words, addressing 1234yf and 1336mzz-isomers under REACH is legally questionable. Other legal tools, outside of REACH, must therefore be deployed to curb TFA emissions without unnecessary impacts on EU climate objectives.

Conclusion & Way Forward

This brings us to the following conclusions:

REACH Annex XVII restriction is *not* an appropriate regulatory management option (RMO) for 1234yf & 1336mzz-isomers:

- The uses of three F-Gases fulfil the definition of "essential" within the meaning of the Montreal protocol – the only existing valid legal definition at this point: they have a proven *"health, safety and societal benefits"* while *"no acceptable alternatives have been identified"* from an economic, safety and technical standpoint.
- Legally speaking, the restriction criteria set out under Article 68 REACH regarding F-Gases are not met since none of the F-gases meets the criteria for persistency (P) or mobility (M, yet to be defined), or any other hazard property. Furthermore, even if they were to meet such

criterion, *quod non*, the P or M criterion alone is not a relevant hazard class within REACH to justify an RMO. Finally, the vPvM criterion is not a formal hazard class neither under the REACH Regulation nor under the CLP Regulation.

- Refrigerants hardly contribute to the build-up of TFA in the environment, with only 5 % of the projected TFA environmental exposure being man-made, including from pesticidal and pharma industries which is less investigated (UNEP, 2016; UBA, 2021).
- Measures at REACH level would still provide little regulatory added value due to continuously evolving industry emissions standards:

The F-Gas regulation proposal addresses adequately eventual emissions of F-gases (and, indirectly, of TFA) to the environment and protection of human health. Direct Links to the MAC Directive 2006/40/EC ensures sectoral coherence. As such a robust system of controlling emissions for F-Gas is already in place and a potential restriction of F- Gases under REACH should not be extended.

- Additional emissions control measures have been implemented in the EU Commission proposal of the F-Gas Regulation, released on April 5, 2022.
- Prevention of emissions extends now to HFOs in Annex II Section I. and is imposed on all relevant actors during the production, storage, transport, manufacturing and operation of F-Gases and the equipment containing them.
- Leak checks and record keeping also covers gases listed in Annex II Section I. Recovery obligations of fluorinated greenhouse gases is extended to also cover foams in sandwich panels and laminated boards when removed from buildings.
- Over the recent decade, the F-gas industry has unilaterally implemented major technical improvements to curb indirect TFA releases. During production there are almost no emissions of these substances. Containment measures are in place during products use. Recovery obligations, depending on economic feasibility are increasingly implemented at the end of life.

A consistent approach should be based on a further reinforcement of well-proven leakage controls systems applicable to older generations of refrigerants, as proposed by the EU Commission. A rigorous and structured implementation is critical to ensure a harmonized approach across EU 27 member states.

The implementation of measures to monitor and stop illegal trade need further clarification & upgrade:

- Member states customs to carry out appropriate import controls (includes staffing, know-how & equipment). Dedicated customs offices for clearance of FGASs. It is unclear how this gets implemented, assuring right know-how level and harmonization across EU.
- Quota fees should not be in place before enforcement is ensured and should be 'earmarked' for curbing illegal imports.
- Penalties: a minimum penalty threshold is needed. The adoption of EU law in EU member states legislation can take several years.
- Single-window integration steps to drive real-time functionality for customs is missing.

- Clear instructions to customs: the frequency & procedure of customs checks is not clearly defined. An uneven implementation could lead to certain countries being targeted for smuggling
- Curbing illegal imports of refrigerants (e.g., illegal import of 1234yf in 2021 are estimated to be at the level of 300 tons). For instance, EFCTC estimated that up to a third of the EU HFC market in 2019 was made up of illegal imports.
- In December 2021 the Commission came up with a proposal to review Environmental Crimes Directive 2008/99/EC proposing to address “illegal production, placing on the market, import, export, use, emission or release of fluorinated greenhouse gases” by classifying this as a criminal offense.

Finally, as there are no technical and economical feasible alternatives for all applications to HFO-1234yf & HFO-1336mzz-isomers, an immediate ban on the three F-gases would harm Europe’s long-term decarbonization objectives in addition to creating negative economic impacts on the whole value chain using the three substances. A socio-economic analysis is currently being elaborated by Chemours in this regard.