Expert Summary Reports – comments from The Chemours Company FC, LLC - Thermal and Specialized Solutions segment.

Thank you for providing summary reports for each sector of the corresponding Call for Evidence questionnaire. It was useful to have a clear understanding of the methodology and definitions used in the authorities' analyses. After carefully reviewing these reports with our internal experts, we would like to share some of our observations for your consideration.

Below, you will see a set of comments in which we highlight parts of the summary reports where our data on the F-gas market differs from the relevant report drafted by REACH-competent authorities and their consultants. We hope for the opportunity to clarify these comments should it be helpful, to ensure a shared complete and accurate understanding of the F-gas market in Europe.

Contents

PFAS Production (Manufacturing) – Comments on Consultation Report Summary

Link to report summary: https://bit.ly/3mTQw9Y

[Page 3, 1.1 Objectives of the study]

- Page 3, Section 1.1 details the study's methodology, including the 152 stakeholders invited by email to participate in the project. When describing unsuccessful efforts to identify and contact Asian PFAS stakeholders, however, no quantifiable specifics are provided. It would be helpful to know the total number of Asian PFAS stakeholders that were contacted to participate and the actual number that did participate. If the total number of Asian PFAS stakeholders invited to participate cannot or will not be disclosed, then please provide the percentage of the total stakeholders (152) that were Asian.

- Page 3, Section 1.1 also notes the study team asked survey respondents to classify their reported substances into one (or more) of 23 groups, as described in work carried out by the OECD. We recommend including a link to the referenced report to provide context and clarify which 23 groups the OECD identified.

[Page 6, 2.1 Annual EEA (EU27+NO/IS/LI/UK) production/processing tonnage volumes (last 15-20 years)]

- Page 6, Section 2.1, *Table 1: PFAS manufactured/processed in the EEA (in tonnes)* lists PFAS manufactured or processed in the EEA, but neither the table nor the referenced literature include a time-period to contextualize how current the production figures are. This context is necessary and highly relevant to appreciating the data because there was an aggressive phasedown in the EU due to the F-gas Regulation, effective 1 January 2015. Hence, production figures for F-gases are vastly different in 2015, 2020 and so on. Without this context, we are concerned that the provided production figures may not be correctly reflected in this Table.

- Page 6, Section 2.1, *Table 1: PFAS manufactured/processed in the EEA (in tonnes)*, it would also be helpful to understand how F-gas is being defined in this context.

[Page 7, 2.1.1 Literature Review]

- Page 7, Section 2.1.1, *F-gases,* claims that HFCs, in particular HFC-134a, is produced in "negligible quantities" in EEA and are therefore not reported. Based on our understanding of the market data, we agree that the ECHA registration likely exceeds 10KT. Further, it is known that there is production/capacity of HFC-134a in Germany on an industrial scale. Given these figures, it would be helpful to understand what constitutes "negligible" in this context, and what threshold is being used to determine it.

- Page 7, Section 2.1.1, *F-gases,* also notes that the EU's capacity for production of HFC-152a is around 5,000 tonnes and overall, in 2012, the EU consumption was less than 10,000 tonnes. However, based on available market data, this figure may be overstated. There is no known production of HFC-152a in the EU and according to the EEA Report No. 15/2020, the total supply to the EU was 3100MT in 2019.

- Page 7, Section 2.1.1, *F-gases,* also claims that the EU is the only region that produces HFC-365mfc, with 15,000 tonnes produced per year. However, this figure is likely overstated given the available market data for this particular compound. According to EEA Report No. 33/2016, the EU supply of HFC-365mfc was approximately 6KT in 2014. We recommend reevaluating for accuracy.

- Page 7, Section 2.1.1, *Remaining PFAS,* details production capacity estimates for PFHxS in kilograms. Given our knowledge of the industry and vast production quantities of this particular compound market, we believe PFHxS estimates should instead be captured in kilotons. We recommend reevaluating these metrics for accuracy.

[Page 8, 2.2 Annual EEA import volumes (last 15-20 years)]

- Page 8, Section 2.2, *Table 2: PFAS imported in the EEA from third countries (in tonnes),* consults various different data sources to calculate the quantities of fluoropolymers, F-gases and other PFAS imported into the EEA from third countries, including the Call for Evidence responses, data retrieved from Eurostat's International Trade in Goods database, and a literature review. In the summary table, however, the tonnage for Fluoropolymers, 21,500, is sourced from 2015 and the tonnage for F-gas is listed as 84,284, without a year. According to our understanding of the literature, the figure for F-gas is 2019 data from EEA Report No. 15/2020.This would mean that the summary table is consulting data, not only from different sources, but also different time-periods. This presents a concern as comparing different time periods may distort the data and result in misleading conclusions.

[Page 9, 2.2 Annual EEA import volumes (last 15-20 years)]

- Page 9, Section 2.2, *F-gases,* points to data from the EEA 2020 Report on Greenhouse Gases that show that total imports of fluorinated gases have "seen a decrease in the years preceding 2017-19." The paragraph then explains how import amounts decreased in 2019, when compared to 2017. Given the provided context, it is not immediately clear if "decrease" and/or "preceding" are misplaced and misconstruing the significance of this data. We recommend updating this language and clarifying if the intent was to compare import numbers in 2017 to 19 to years prior.

[Page 9, 2.2.1 Eurostat data]

- Page 9, Section 2.2.1, *Table 2: A summary of annual imports of PFAS chemicals from third countries into EU27 (tonnes),* is marked as the second table in the report but, based on preceding and succeeding data sets, it is clearly the third. We suggest updating the table label for clarity.

- Page 9, Section 2.2.1, *Table 2: A summary of annual imports of PFAS chemicals from third countries into EU27 (tonnes),* states that the import and export information gathered through the Eurostat source only represents approximately ¼ of all legal imports. Although we would agree with this statement, we believe that using the data from the EEA Report No 15/2020, Fluorinated greenhouse gases 2020 for imports and exports, as well as production, is more consistent.

[Page 10, 2.2.1 Eurostat data]

- Page 10, Section 2.2.1, *Table 4: A summary of annual imports of PFAS chemicals from third countries into EU27 (tonnes),* cites F-gas volumes for 2019 at 10,371T. according to EEA Report No. 15/2020, however, F-gas volumes for 2019 were 26KT, making the included figure vastly below what's recorded in available public literature. We recommend reevaluating the data set for accuracy.

[Page 11, 2.3 PFAS production in the market]

- Page 11, Section 2.3, *Table 5: Main global manufacturers of Fluoropolymer, F-gas and other PFAS,* details the market share of major manufacturers of PFAS and fluoroplastics, along with their operational locations. We noted that the source listed for Table 5 only captures fluoroplastics and does not include F-gases, rendering it incomprehensive for this particular data set. We suggest consulting another source for a clearer, more accurate assessment of manufacturing locations.

    - Concerning Chemours, it is listed as having locations in Germany, Japan, China, the Netherlands, and the US. This is incorrect. Chemours does not have any production locations in Germany or Japan.

Application of Fluorinated Gases (F-Gases) in the European Economic Area – Comments on Consultation Report Summary

Link to report summary: https://bit.ly/3v8REKF

[Page 4, 2. Introduction]

- Page 4, Introduction, *What are per- and polyfluoroalkyl substances (PFAS) and fluorinated gases (F-gases)?* The definition of PFAS for this work covers any substance containing at least one -CF2 or -CF3 group within its chemical structure. We believe this definition is outdated and should be updated.
- Page 4, Introduction, *Why is there concern about them*? While we understand the concern regarding the persistence of some PFAS and that of their degradation products, we believe that these concerns have been addressed by requesting independent studies about TFA degradation related to R-1234yf and to R-134a.

[Page 5, 3: Overview of the use of F-Gases and Emissions]

- In general, we believe it is important to address in this section that early ammonia, methyl-chloride and sulphur-dioxide refrigeration systems were the cause of numerous casualties. In particular, the high number of casualties due to ammonia intoxication led to leave refrigerators in backyards and triggered the need for the development of safer compounds, later called Freon™.

[Page 6, 3. Overview of the use of F-Gases and Emissions]

- Page 6, *First Paragraph:* Greater specification regarding which substances degrade into persistent substances such as trifluoroacetic acid (TFA) is needed.
- Page 6, *First Paragraph*: When discussing the possible adverse environmental effects of persistent substances, we believe it is important to reference the naturally occurring TFA in oceans, as well as specify which reports contradict these findings as they are currently not specifically identified.
- Page 6, *Table 1 Annual Usage, Stocks and Emissions of F-Gases in the EU27+Norway+UK:* We have seen some inconsistencies in the figures reported in the 2nd Stakeholder Consultation Questionnaire comparing the data from the Exponent International Report, the Report Summary F-Gas Uses and the Report Summary Transportation. As an example, on page 136 of the 2nd Stakeholder Consultation Questionnaire, the total F-gases in the car park is estimated to be 184,130 MT, where on page 6 of the Exponent International Report, the amount in stock is 115,763 MT.
  Regarding emissions, in the 2nd Stakeholder Consultation Questionnaire on page 136, the annual emissions are estimated to be 9,000 MT, which is aligned with the information in the Report Summary F-Gas Uses and the Report Summary Transportation, however on page 116 of the 2nd Stakeholder Consultation questionnaire it is estimated as 11,726 MT, which is aligned with the Exponent International Report.
  We believe it is important that there is consistency in the numbers used in the different sections of the 2nd Stakeholder Consultation Questionnaire and amongst the expert summary reports.

[Page 7, 4.1 Refrigeration, Air Condition and Heat Pumps]

- The market segmentation given is too wide. It would be more useful if specifics of each subsegment were provided. More specifically, each macro-segment mentioned here should be split into application segments identified by specific needs, available alternatives and socio-economic analysis of non-F-Gas alternative technologies. We suggest the following breakdown:
    - Dividing Industrial Refrigeration into 2 to 3 sub-applications.
    - Subdividing Heat Pumps following the EHPA segmentation format, i.e. A-A; G-W; and A-W. A-W could be further split into outdoor Monoblock and split applications.
    - Dividing Transport Refrigeration into trucks, trailers, small trucks, railways, marine applications and air transportation.
    - Analyzing Heat Pumps for tumble dryers separately from industrial dryers with the creation of a Home Appliances segment composed of tumble dryers, dish washers and washing machines.
    - Industrial Dryers.

[Page 8. 4.1.1: Trends in Refrigeration, Air Conditioning and Heat Pumps]

- Page 8, *First Paragraph on this Page:* It would be valuable to mention that R-1234yf is the main refrigerant now used in mobile air conditioning of new cars.
- Page 8, *Last Paragraph of Section:* Per our own analysis, Chemours has not seen a market movement towards lower GWP HFO options in residential or commercial building applications.

[Page 8, 4.1.2: The Use of Alternatives in Refrigeration, Air Conditioning and for Heat Pumps]

- Page 8: Broadly speaking, for each application segment, the non-identification of a satisfactory alternative should lead to a socio-economic analysis of the consequences of such extended restriction. Chemours provided its expert views on the risk of using alternatives for key segments, which do not seem to have been taken into consideration in this report. Our expert view shared with 4 of the 5 national competent authorities on June 24, 2021 have also been omitted. The safety aspects of “alternatives” are largely underestimated and very lightly scrutinized in the RoI (See notes in the HVACR and Transport documents for detailed actions).
- Page 8, *Bulleted List*: It is important to specify what is the size of the charge when mentioning that larger ‘charge sizes’ pose a risk of flammability when hydrocarbons are used in larger quantities.
- Page 8, *First Paragraph after Bulleted List*: It would be of great value to further elaborate on the specific areas where alternatives are unable to provide the conditions required for some processes. In particular, more detail should be given on resource efficiency and using CO_2 as a refrigerant in hypermarkets in high ambient temperatures. In our experience, an additional piece of equipment would be needed for the condenser needs to be cooled down (to be able to reach an acceptable level of efficiency for the system to operate,) and/or an additional receiver is required for storing the CO_2 in stand-still mode . When adding the above together, more resources are needed to design, install and maintain the refrigeration system running on alternatives vs using a F-gas solution with low GWP.

[Page 9, 4.1.2: The Use of Alternatives in Refrigeration, Air Conditioning and for Heat Pumps]

- Page 9, *First Paragraph on Page:* Greater detail on steps taken to reduce the risk of damage to the cooling circuits of split units (part inside and part outside a building) is needed.
- Page 9, *Second Paragraph, Last Paragraph of Section*: We echo the sentiments that industry has previously raised that the cost of using CO_2 in mobile air conditioning is too high.

[Page 10, 4.2.2: The Use of Alternatives for Foam Blowing]

- Page 10, *First Paragraph:* We believe the first statement that F-gases are persistent is not correct. H(C)FOs are not persistent and have very low degradation of F-gases to TFA. Reference: Published evidence supports very low yields of TFA from most HFOs and HCFOs - Fluorocarbons https://www.fluorocarbons.org/publication/published-evidence-supports-very-low-yields-of-tfa-from-most-hfos-and-hcfos/

[Page 10, 4.3 Solvents – Trends and Alternatives]

- Page 10, *Second Paragraph*: It is important to mention that some alternatives have health concerns and regulatory restrictions.

[Page 13, 4.6.1 Trends in Fire Suppressants]

- Page 13, *Paragraph 2:* It is important to clarify that while the trend from HFCs to HFOs does not apply to Fire Suppressants, the reason is not because HFOs are flammable, as the report suggests. As a matter of fact, an HFO considered in this space is 1336mzz, which is non-flammable.

[Page 15, 7. List of PFAS substances mentioned in this report]

- The non-flammable HFO-1336mzz(Z) is missing in this table. Chemical name: cis-1,1,1,4,4,4-hexafluoro-2-butene

Report summary F-gas uses – Comments on Consultation Report Summary

Link to report summary: https://bit.ly/3lLlr9n

[Page 3, 3. Tonnage Band]

- Page 3, Section 3 explains how market data on F-gases filled into new products and in stocks each year are primarily sourced through data collated by the "European Union (EU)/European Economic Areas (EEA) Governments (the Greenhouse Gas (GHG) inventory data) in their annual reporting to the UNFCCC (EU, 2020a)" and depicted in Figure 1. However, the cited data clearly stems from different sources rather than solely the annual EEA report on Fluorinated greenhouse gases 2020. We recommend revisiting the information sources is as it could pose consistency, coherence and standardization issues. In addition, it's unclear why domestic refrigeration demands were 122t of F-gases for new products in 2018 since the (EU) 517/ 2014 has banned the placing on the market of HFCs with GWP of 150 or more since January 2015 and most of the viable refrigerants do not meet the 150 GWP threshold.

- Page 3, Section 3 also breaks down the tonnage of F-gases by stage, whether it is filled into new products or found in operating systems. According to the F-gas summary report, 19,724 tonnes/a F-gases remain in products at decommissioning but there is no further explanation on end-use. It would be helpful to have additional information on what has been done with the remaining F-gases that are in products at the time of decommissioning and how the product is dealt with.

[Page 7, 5. Manufacturing & market price + market development Objectives of the study]

- Page 7, Section 5 details market data for fire detection and suppression, indicating strong growth over the period of 2018 to 2025 (Research and Markets, 2019). However, 'Clean Agent Suppression' from F-gases is a very small, specialty portion of the fire detection and suppression market. We estimate that 'Clean Agent Suppression' in developed countries has declined steadily since 2010.

[Page 7, 7. Emissions]

- Page 7, Section 7 claims that the estimated total emissions of F-gases from the "different sub-applications" may be found in Appendix III. However, Appendix III only lists domestic, commercial, industrial, and transport refrigeration, as well as mobile air and stationary air conditioning and heat pumps. The listed applications in Appendix III are main sectors, not the described sub-applications. For example, a sub-application would be residential heat pumps. We recommend revising Appendix III for accuracy.

[Page 8, 7. Emissions]

- Page 8, Section 7 unpacks how HFOs are being used commercially compared to other F-gases and notes that the majority are used as a single substance (rather than a blend) in mobile air conditioning (MAC) systems for passenger cars and in light goods vehicles and commercial refrigeration, commercial air conditioning, heat pumps and process cooling. While it is true that MAC systems are using a pure HFO, blowing agents for foams are using pure H(C)FOs as well. However, the other main sectors, e.g. commercial refrigeration, are using HFO/ HFC-Blends.

- Page 8, Section 7 also provides quantitative measures for HFO emissions from passenger and light goods vehicle MAC in 2018. According to the summary, emissions from manufacturing ranges from 9 – 1,170 tonnes/a, and emissions from stocks range from 1,281 – 17,472 tonnes/a. However, that is the extent of the context provided for these ranges, omitting critical information. The summary does not provide contextual reasoning for either figure range. And, for manufacturing there is a vast delta that contradicts our understanding of the facts. Manufacturing of F-gases is expected to have very low emissions and the given figure ranges are incongruent with that expectation. We suggest revising this Section for accuracy and to provide clear and understandable facts, especially since these emissions findings are reported annually to the national authorities and are included in the GHG emission inventory reports to national authorities.

[Page 8, 8. Worker exposures]

- Page 8, Section 8 deals with worker exposures to F-gases and notes that in plant manufacturing or when putting gases into product, exposure should be small given the need to use closed systems, a point made by numerous respondents. Outside of the manufacturing plants, the study argues that there may be greater exposure for workers, including at sites reclaiming refrigeration equipment at the end of its service life. This assertion, however, is incorrect. Exposure during end of life recovery and recovery for reclamation is comparable with servicing exposure during operation. Further, it is worth noting that any rise in exposure outside of manufacturing plants may very well be due to non-adherence to industry best standards and practices for such work. Best handling practices exist with demonstrably positive outcomes in EU Member States. When these practices are applied appropriately, emissions outside of manufacturing plants, even during reclaiming and end of life operations, would be reduced considerably.

[Page 8, 10. Alternatives]

- Page 8, Section 10 delves into the alternative non-PFAS substances and technical methods that were identified for different applications given the pivot away from F-gases for certain uses. While the summary asserts that domestic refrigeration has moved away from a near total reliance on F-gases to an almost total reliance on alternatives, Appendix III estimates that the demand of F-gases for domestic refrigeration is still 122T in 2018. If the sector has phased out F-gases and is nearly completely reliant on alternative substances, it is not immediately clear why 122T is still being used in new products. It would be helpful to have clarity and additional context on this data.

- Page 8, Section 10 also notes that the clothes dryer heat pump market is similarly pivoting away from F-gases to alternative substances. If this assertion is correct, it would be helpful to understand how this is feasible for commercial tumble dryers with higher charge sizes, which would inevitably impact the safe use of any alternative substance.

[Page 9, 10. Alternatives]

- Page 9, Section 10 continues discussing the switch to alternatives across various applications and notes that there is strong resistance to pivoting to alternative-use in the mobile air conditioning market, with stakeholders citing safety concerns around hydrocarbons and cost concerns for CO2. It would be helpful to understand how cost is being quantified in this context. While there is final equipment cost in the market, there is also environmental costs of manufacturing, which is more complex, and costs related to labor-intensive equipment.

- Page 9, Section 10 also points to Appendix VII for an assessment of alternatives for each sub-application of F-gas. This section notes that major constraints with these options include safety, technical factors and legislation, but omits another significant factor for consideration when evaluating alternatives, that of indirect environmental impact. Any alternative being considered should also be evaluated in the context of sustainability, including resource efficiency, and environmental impact for a comprehensive and truer comparison.

[Page 9, 11. Economic impacts in case of a full PFAS ban]

Page 9, Section 11 unpacks the economic impacts of restriction of PFAS and claims that F-gas blowing agents are more expensive than the alternatives, with HFOs relative to CO2 mixes having a cost differential of x10 according to stakeholder responses. Though the summary posits this as a strong rationale for switching to alternatives, it is worth noting that this is not the present trend and thus not a fully accurate picture for the current cost state.

Page 10, 11. Economic impacts in case of a full PFAS ban]

- Page 10, Section 11, *Table 1: The trend development and economic impact for each of the different sub-applications* explains the trend development and economic impact for each of the different sub-applications and there are several opportunities for additional context or clarity, specifically:

  - For commercial refrigeration, this application needs to be divided into several sub-sectors, including hypermarkets, supermarkets, discounters, condensing units, integrals and by ambient conditions as the trends and impacts will differ and vary greatly depending on the sub-sector. There are also differences by region, with variances including higher ambient conditions and affordability. The summary also claims that there is growing acceptance of the use of alternatives, namely CO2 and hydrocarbons in mid- to large-scale facilities in the sector, but this does not appear fully correct. According to our understanding of the industry, CO2 is not a preferred option and hydrocarbons have a charge size limit of 500g, limiting its applicability in this context.

  - For commercial refrigeration, the summary also notes that the lifetime of medium and large equipment spans up to 15-25 years, and that it would take 10-12 years to bring new products to the market. Beyond timelines, it is also important to note that these new products would in many cases have higher costs and higher environmental impacts than the solutions they are intended to replace, both in terms of energy consumption and manufacturing environmental cost. Resource efficiency must be included in this assessment.

- For industrial refrigeration, the summary posits that absent restriction, baseline F-gas use is declining in favor of ammonia systems. This is not representative of the entire industrial refrigeration spectrum, however, as ammonia is not an alternative for the majority of applications. There is a clear industry convergence towards HFOs like R-1234ze for multiple chiller applications, mainly due to its energy and cooling performance, as well as its safety benefits. We would also mention the safety concerns linked with ammonia, including high toxicity and flammability. We recommend that this context be included to give a clearer picture of this segment.

- For industrial refrigeration, the section admits that continued use of F-gases is likely to be required to reach and maintain certain operating temperatures and the fact that F-gases still provide the most cost-efficient option for some specific applications. We should also note that F-gases provide the highest system efficiency and thus, the lowest environmental impact as compared to equivalent CO_2 emissions generated by energy consumption.

- For transport refrigeration, the section posits that the sector will likely switch to HFOs in the absence of an F-gas restriction given the high demand for refrigerated transport. Based on our understanding of the industry, this pivot is likely to be towards HFO-blends rather than pure HFOs.

- For transport refrigeration, the section also notes that some alternatives are already in use in trucks, trawlers and in reefer containers, although currently not widespread. Listed barriers to widespread alternative adoption include size limitations, which are problematic for the use of active CO_2 systems given the layout of existing trucks. Beyond size, however, cost and performance limitations should also be considered as barriers to alternative adoptions in the event of a PFAS restriction. It is also worth noting that concerns related to CO_2 systems extend beyond "existing trucks" and should also include refrigerated truckload trailers.

- For transport refrigeration, the section admits that use of hydrocarbons in enclosed areas may generate risks of flammability but fails to mention that the use of flammable refrigerants is simply not allowed aboard vessels and is subject to limitations on trains and in terminals, storage areas and metropolitan areas. Use of such an alternative in this application would also generate considerable regulatory changes.

- For transport refrigeration, the section also claims that there are significant gaps in the market, meaning that reliance on F-gases in road transport refrigeration is likely to continue for some time. We must be cognizant, however, that this gap goes beyond just road transport refrigeration and includes sea and railways as well

- For mobile air conditioning, major barriers for use of F-gas alternatives go beyond safety, toxicity and cost. Performance is also a factor. For alternatives such as CO_2, we must also note that end-user cost increases would likely be long-term and ambient temperature limitations would have to be overcome by new technological solutions.

  - For mobile air conditioning, the section also mentions do-it-yourself kits for topping up MAC systems that may result in significant releases to the environment. To fully appreciate this anecdote, it would be helpful if more information and context was provided about these kits' performance and use.

[Page 11, 11. Economic impacts in case of a full PFAS ban]

- Page 11, Section 11, *Table 1: The trend development and economic impact for each of the different sub-applications* continues to unpack trends and economic development by application. Additional areas in need of amendment and clarification include:

  - For domestic AC and domestic heat pumps for space heating, the section notes that building codes may need to be revised and precautions need to be recognized when considering a switch to fluorine-free alternatives. We want to note that spaces being accessed by people present certain limitations related to the safety risk for alternative adoption as well.

  - For domestic AC and domestic heat pumps for space heating, the section also notes that certain stakeholders raised concerns that there is no alternative to HFOs, specifically R-1234yf, for the heat pump market because of the safety concerns related to hydrocarbons. We noticed that neither R-32 nor blends are mentioned in this context. It is not clear why they were not mentioned, and we would request that it be included to ensure a comprehensive assessment.

  - For commercial AC and heat pumps, the section notes that propane is currently mostly restricted to small applications because of building codes and other regulations that limit charge size. However, this is not the full case. These applications require larger charging sizes or they won't be suitable for CO_2 given the resulting cost and resource inefficiency. Further, alternatives in this context present major safety concerns related to fire and explosion risk and this caveat should be noted, not ignored.

  - For propellants (non-MDI), the section notes that, when considering alternatives, some safety constraints should be recognized. Just as the succeeding Section 12.1 *Other impacts in case of a full PFAS ban* notes, an increased use of hydrocarbons would increase atmospheric loading with volatile organic compounds. This caveat should be reiterated in the impact section of Table 1 for propellants as well.

[Page 12, 12.1 Other impacts in case of a full PFAS Ban, Environmental]

- Page 12, Section 12.1 lists emissions as a key environmental impact of switching from F-gases to alternatives but admits that increased use of hydrocarbons would increase atmospheric loading with volatile organic compounds (VOCs). This is important to note because it demonstrates how even the chemistries with perceived low-concentration emissions can have detrimental environmental impacts. This section also notes that the severity of this problem is dependent on the quantity of propane that may leak from systems. If this argumentation is reasonable for hydrocarbons, then it must also be applicable for TFA, a naturally occurring substance that can also be produced by the breakdown of some HFCs or HFOs.

- Page 12, Section 12.1 admits that a major health concern regarding a pivot from F-gases is the risk of fire. It is not just fire that is the concern, however, it is also, and perhaps more worrisome, the risk of explosion. We recommend this caveat be included for proper context.

[Page 12, 12.2 Other impacts in case of a full PFAS Ban, Social impacts]

- Page 12, Section 12.2 lists reduced employment through loss of market share for EU companies as a social impact of a full PFAS ban. We should also consider the impact on small to medium-sized companies (SMEs) that would not be able to afford the expensive investments necessary to accommodate a radical technology change if PFAS is removed from the market.

[Page 13, 12.2 Other impacts in case of a full PFAS Ban, Social impacts]

- Page 13, Section 12.2, *Table 2: Summary of availability of alternatives to the use of F-gases in New HVACR Systems* summarizes the availability of alternatives to the uses of F-gases in new HVACR systems and there are several opportunities for additional context or clarity, specifically:

    - For domestic AC and heat pumps, hydrocarbon-based alternatives are listed as new products already on the market, though there are calls for relaxation of the limits on charge size. The summary fails to mention, however, that those limits are in place for proven safety reasons. We recommend including this caveat for fair and comprehensive analysis. The details for this section also list specific situations where alternatives may continue to be problematic, including use in high rise buildings, where the risks of accidents may exceed the risks from emissions of F-gases. This is an important caveat to note since applications within this subsector that have charge limits exceeding 500g may not have the option to switch to alternatives. For example, some national and local building codes are not currently supporting hydrocarbon usage for this application. To ensure this detail is adequately captured, domestic AC and heat pumps must be divided into application segments, charge sizes and analyzed by regional/local differences.

    - For commercial HVACR, this sub-use is a substantial sector and should be divided into application segments, charge sizes and analyzed by regional and local differences to ensure all nuances are captured. Further, the summary points to further research being conducted “in a number of areas”. Additional information as to what these “number of areas” are would provide further insight into the available options in this sector. It is also critical to note that alternative solutions like CO_2 or hydrocarbons are not applicable for the entire spectrum of this sector and even where it is applicable, there are significant costs to consider including higher energy consumption which in turn leads to greater environmental impact in terms of CO_2 equivalent emissions.

- For industrial heating and cooling, the section notes that efficient systems based on ammonia have been in place for many years. And, while other alternatives to F-gases are also practical for some industrial applications, there may be situations or processes where the continued use of F-gases is required due to toxicity and flammability concerns linked to the use of Ammonia. We recommend including this detail for full context.

- For electronics cooling, the summary notes that very small systems may be cooled using basic ventilation or small-scale AC systems for which hydrocarbon charge size would not be problematic. However, this does not account for the safety concerns linked to the use of a highly flammable refrigerant. For full context, we recommend including this caveat.

- For transport refrigeration, the summary notes that some alternatives are already in use in trucks, trawlers and reefer containers but such use is currently not widespread and specific barriers affect the sector, including size limitations that are problematic for the use of active CO_2 systems given the layout of existing trucks. This problem also applies to hydrocarbons. We must also note that this is an issue of safety as well, specifically the safety restrictions applying to multi-modal transportation. Further, these limitations will be compounded by regulatory changes and additional costs that will be projected on consumers if PFAS is restricted.

- For mobile air conditioning, the section includes an €300 estimate for the cost of adopting CO_2 MAC systems per vehicle. We would appreciate additional clarity as to how this estimate was reached, given the variations in car model, size and design.

- A footnote is included for both commercial HVACR and industrial heating and cooling that states “the distinction between industrial and commercial HVACR is not clear cut” and “a regulation on either sector would need to define very clearly what was covered.” We support this comment and would also want regional sub-group differences to be analyzed

- When mentioning restriction scenarios envisioned, namely “mainly total phase-out of PFAS-based F-gases" it is important to also consider F-gases that might not fulfill the PFAS criteria in the future.

[Page 14, 13. Methods used & uncertainties]

- Page 14, Section 13 explains that emissions are calculated by multiplying activity data by emissions factors. Emissions factors can be either default or specific to a country, application or sub-application. According to the summary, the methodology for Member States to collect and compile this data has been published in the Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories (IPCC, 2006). However, more information on how the data is being aggregated and what process is being used would be helpful to understanding the data.

- Page 14, Section 13 also lists uncertainties, including GHG inventory data, which we believe is incomplete. Companies that are not required to report under the F-gas regulation do not have access to the reporting tools and therefore any F-gases that they might destroy will not be included in the reporting. Another element which is not included is the recycling of F-gases. There is no tracking of the amount of F-gases that are recycled in the field and are therefore not emitted or destroyed. EEA Report No 15/2020, Fluorinated greenhouse gases 2020 contains data reported by companies on the production, import, export and destruction of fluorinated greenhouse gases.
- Page 14, Section 13 argues that there is unclarity if the application stationary air conditioning includes F-gases used in heat pumps. However, in Appendix II and III we believe that heat pumps are included in the reported data. Further clarity needs to be shed on this information.

[Page 15, Appendix I]

- Page 15, Appendix I includes a list of F-gas substances identified in commercial use through the assessment. While all F-gases are indeed listed, this compilation ignores the renewed definition. Under the renewed definition, HFC-32 should not be included. We suggest culling Appendix I for F-gas substances that do not meet the criteria for the renewed definition or highlighting in some way which F-gas substances no longer meet the renewed definition to ensure accuracy and clarity.

- Page 15, Appendix I lists specific F-gas substances by substance, code and structure. Several F-gas codes are listed twice, however. Specifically, F-gas codes HCFO-1233zd(E), HCFO-1224yd and HFO-1234ze(E) are listed multiple times. It would be helpful if this were acknowledged in an accompanying legend or if notes were provided to clarify the repetition if this is not an error.

[Page 17, Appendix II]

- Page 17, Appendix II lists intended applications of the EU-28 total supply of F-gases, sourced from "the F-gas Report (EU, 2020c). For foams, including pre-blended polyols, the values for 2016-2019 do not align with the values listed in Appendix III as "Foam Blowing Agent," for open and closed cells. Appendix II lists supplies for foam for 2016 as 10,157, 2017 as 11,521, 2018 as 11,083, and 2019 as 11,041, but Appendix III lists "new use" emission values of 4,940 and 271 for closed cells and open cells, respectively. It would be helpful to understand how "new use" is being defined in this context. In Appendix III, total emissions closed cells and open cells are also listed as 4,186 and 1,074, respectively. It would be helpful to understand how the values listed in Appendix III and Appendix II are complimentary so the data sets can be fully understood.

- Page 17, Appendix II denotes intended applications of the total supply of F-gases, however, significant quantities of F-gases made in Europe are exported to non-EEA regions. It is unclear if this is accounted for in the data, particularly pre-2015 volumes. Please clarify.

[Page 18, Appendix III. Estimated total emissions of F-gases from the different sub-applications.]

- Page 18, Appendix III denotes the fire protection total emission rate at 3.48% of "installed systems" based on the amount in stocks. Installed fire systems are generally non-emissive by nature and the UNEP Halons technical options committee 2018 assessment report on P 88 estimates the global

emissions rate to be 2.5% in 2018. Given the advancement on service and maintenance of the systems in the EU, we can expect the emissions rate in the EU to be lower than the global estimate. This should be clarified to present a truer picture.
https://ozone.unep.org/sites/default/files/2019-04/HTOC_assessment_2018.pdf

[Page 22, Appendix V]

- Page 22, Appendix V lists estimations for quantities of hydrofluoroolefins used as a proportion of F-gases in products and equipment for EU-28 (2018) and points to a source (EU, 2020c) that is not available. We recommend making this source document available for review, reference and appropriate context.

- Page 22, Appendix V includes a note at the end of the chart with a caveat that HFOs are mainly used in mobile air conditioning and commercial refrigeration, based on stakeholder discussions. Needs to be noted that HFOs are also used as Blowing Agents for foam.

[Page 23, Appendix VI]

- Page 23, Appendix VI estimates emissions of HFOs in 2018 from passenger cars and light goods vehicle mobile air conditioning, however the lack of detailed information provided is not substantive enough to glean clear conclusions.

[Page 24, Appendix VII]

- Page 24, Appendix VII lists identified alternatives to F-gases in the HVACR market, separated into sub-application. Though the listed applications include domestic refrigeration, commercial refrigeration, industrial refrigeration, electronics cooling, transport refrigeration, stationary air conditioning, mobile air conditioning and heat pumps, it is far too limited. There are many more applications that differ by region, affordability being a factor, and ambient temperature with system temperature being another factor. Any comprehensive assessment of the availability of fluorine-free alternatives in this market needs to be far more specific to present a full view.

Electronics & energy – Comments on Consultation Report Summary

Link to report summary: https://bit.ly/3aBrSFs

[Page 3, 1 Uses / Applications]

- Page 3, Section 1: The section details the uses and applications of PFAS and particularly fluoropolymers. However, we believe that the study failed to consider the uses of sulfur hexafluoride (SF_6) in electric power supplies, which according to the Life Cycle Assessment (available here: https://unfccc.int/sites/default/files/wamatt051_1.pdf) the use of SF_6 technology presents considerable environmental advantages over the use of SF_6-free switch gear.

[Page 4, 3 Tonnage Band]

- Page 4, Section 3: The SPIN database suggests that the most widely used substance in the electronics industry in the United States and the Nordic countries is hydrofluorocarbon 1H-pentaflouroethane, which is mainly used as a heat transferring agent and cooling agent, which is a substance that is already regulated by the EU F-gas regulation.
- Page 4, Section 3: It was difficult to discern the volume because markets have clearly been mixed. For example, the SPIN database has a combined category for flame retardants and extinguishing agents, making it impossible to distinguish between them. Greater detail on the breakdown of these categories would be useful to providing a deeper assessment.

[Page 5, 3 Tonnage Band]

- Page 5, Section 3: We believe a deeper breakdown of the 4,475 calculated tons of PFAS in dust from e-waste dismantling areas would be beneficial especially between PFAS polymer and non-polymer PFAS .
- Page 5, Section 3: The report predicts that for immersion cooling the current EEA market is said to be 0 tons, with a potential of 1,100 tons in 2025. Volume outlook is difficult to predict, however. The technology is only emerging and still under development. Two technologies are emerging with single-phase liquid or two-phase liquid cooling and it is unclear what each of their adoption will be.

[Page 6, 3 Tonnage Band, Table 3]

- Page 6, Section 1, Table 3, *Batteries:* A narrower breakdown of the category would be helpful to better evaluate the tonnage provided.

[Page 8, 5 Manufacturing and Market]

- Page 8, Section 5, *Immersion Cooling*: While the summary report argues that the potential for emissions from two-phase liquid immersion cooling systems is higher, we believe it is important to note that systems can be designed to reduce the fugitive emissions and industry is developing hermetic systems, which imply zero emissions. Technology is still emerging and being developed to reduce the amount of fluid needed, which could reduce costs. This is important because the report argued that the cost of the fluids was higher than the cost reductions provided by the energy-efficiency of the system. Additional benefits of F-gases in immersion cooling include the possibility for recycling and circular-use. (See this EPA industry example with the SF_6 high circular reclaim and recycling: https://www.epa.gov/sites/default/files/2018-08/documents/12183_sf6_partnership_overview_v20_release_508.pdf.)

[Page 9, 5 Manufacturing and Market]

- Page 9, Section 5, *Immersion Cooling*: At the end of the section, regarding PFAS emissions from immersion cooling, the estimated emissions for the EU of 1.1 t/y does not consider how the industry is developing hermetic systems.

[Page 9, 6 Number of Production Sites]

- Page 6, Section 6: We believe it is important to note that major original equipment manufacturers (OEMs) are in the United States. Additionally, we feel like this section should also include production sites in Asia.

Transportation – Comments on Consultation Report Summary

Link to report summary: https://bit.ly/3aBrVkC

[Page 4, 1 Uses / Applications]

- Page 4, Section 1, Table 1: The report's table on "Uses and applications of PFAS in transportation products and articles" states no information is available on fire prevention and protection uses. In fact, F-gases are used as fire suppression systems in military applications, cultural property, data centers and other critical installations. Performance requirements for these applications include electrical non-conductivity and non-corrosiveness, as well as low residues after utilization.

[Page 5, 2 Main PFAS substances]

- Page 5, Section 2, Table 2: The section lists a few examples of F-gases used in transportation but marks the information regarding current use in the EU transport market as "unknown." All new air conditioning systems in cars manufactured in the EU make use of R-1234yf, a low-GWP refrigerant, in compliance with the F-Gas phase down program under the EU F-gas Regulation. R-1234yf blends are also used in a wide variety of transport refrigeration equipment, where those blends have progressively replaced high-GWP refrigerants.

[Page 6, 4 Emissions]

- Page 6, Section 4: The summary report assumes emissions of F-gases to the air of 5% (ERC 9b Widespread use of functional fluid (outdoor), ECHA 2015), for a total estimated emission of 9,000 t/a of F-gases from HVAC systems for passenger comfort in road traffic. The emissions to air value of 5% is overly conservative and not representative of present industry standards. It fails to reflect the growing trend towards leak-proof A/C systems. Several studies (see our response to the Stakeholder Consultation) indicate operational emission rates <2%/a.

[Page 6-7, 5 Exposure (workers, consumers)]

- Page 6, Section 5: Given there is limited information available to the dossier submitter on PFAS concentrations and exposure to PFAS in transport products, it is important to clarify that the vast majority of transport HVACR equipment are close circuit, sealed systems. Exposure to workers is regulated by handling and maintenance and repair (M&R) procedures. Exposure to consumers, on the other hand, is essentially limited to mechanical accidents.
- Page 7, Section 4, Table 4: The "HVACR-systems in transportation vehicles (F-gases)" subgroup does not take into account refrigerated transport applications outside trucks. These uses include the below applications, but this list is not complete:
    - Reefer containers: Ca. 5kg / unit
    - Refrigerated sea vessels: Ca. 200kg / vessel
    - Refrigerated wagons: Ca. 4kg / wagon
    - Air refrigerated containers: Ca. 0.2kg / container...

[Page 7, 6 Alternatives]

- Page 7, Section 6.1: The summary report accurately states that manufacturers of transportation vehicles do not prescribe the use of individual substances to their supplier but rather stipulate performance specifications the individual parts have to meet. That said, system design is heavily influenced by the thermodynamic properties of the heat-carrying substance. Present generation equipment can hardly allow a substance change without a substantial re-design effort by system manufacturers.
- Page 7, Section 6: The summary report assumes that since the production of fluorine containing materials usually is more expensive compared to most other materials, fluorinated materials are used only where performance requirements leave no other option. This statement ignores two key industry enablers in transportation, however, one being knowledge and know-how and the other being availability of solutions. Furthermore, HVACR total system costs are heavily influenced by the heat-carrying fluid choice made by manufacturers.

[Page 10, 6.5. HVAC-systems in transport vehicles (Alternatives)]

- Page 10, Included in the Alternatives enumeration the Natural Gas HC-600 (n-butane) has been mentioned. It's not a suitable alternative due to the disadvantages of its safety profile and its relatively high boiling point versus the current F-gas solutions. This results in a too low of pressure to support sufficient thermodynamic performance.

- Page 10, CO2 presents a particular challenge in automotive because its pressure is significantly higher in the HVAC system than R-1234yf and HFC-134a, 10 x (Papasavva, 2014). It has been difficult to contain CO2 in the flexible hoses needed to manage vibration during vehicle use. In addition, a leak in the CO2 system can lead to high levels of CO2 in the cabin without being easily detected when inhaling, which could be deadly. In the case of HFOs, the pressure in the system is much lower (10x), hence the amount of refrigerant that can potentially leak into the cabin is much lower. Reference: (Papasavva, 2014, page 8, paragraph 7, CARBON DIOXIDE (R-744)): https://docs.lib.purdue.edu/cgi/viewcontent.cgi?article=2474&context=iracc

- Page 10, Since 2009 the automotive industry made tremendous improvements on the efficiency of its air conditioning systems with the adoption of R-1234yf. ICCT Report (2019, pages 24-25) shows in hotter climate conditions the lifetime emissions of an R-1234yf system are lower than those for a R-744 system. The low GWP R-1234yf technology developed for the automotive industry can also be applied to train rolling stock where a shift to low GWP R-1234yf will offer similar benefits. Reference: http://www.igsd.org/wp-content/uploads/2019/03/ICCT-IGSD-Mobile-AC-2019.pdf

[Page 11-12, 6.6 Interiors]

- Page 12, Section 6.6, Table 5: The table on reported alternatives for PFAS substances used in transport lists advantages and disadvantages of alternatives. It is appropriate to complement this information on the "HVAC-systems in transport vehicles" sub-use section with the following:

- Disadvantages: alternatives can add higher system total carbon emissions, as well as insufficient thermodynamic performance to reach the required scope. Known alternatives can be complex to utilize and maintain, and they cannot provide sufficient levels of equipment reliability. Additionally, many non-PFAS alternatives such as CO2 and water provide lower resource efficiency than systems that run on F-gases.