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From:	General Secretariat of the Council
To:	Working Party on the Environment
Subject:	F-gases Regulation: WPE meeting on 12 September 2023: Technical input from the European Commission

With a view to the meeting of the Working Party on the Environment on 12 September 2023 delegations will find attached a note with technical input from the European Commission.

<u>Analysis of the impacts of the Compromise Packages</u>

This non-paper analyses the four potential compromise packages proposed by the Presidency based on data from the impact assessment and other, more recent studies (as indicated).

The four compromise packages are composed of the following elements:

(1) Full F-gas phase-out in **medium voltage switchgear** (no F-Gases as a first step in cascade with GWP1000/2000 as second step, based on a tendering process);

(2) Full F-gas phase-out for small split systems (**point 18**), cascaded approach GWP150 in 2027/2028 and no F-Gases in 2030+;

(3) Full F-gas phase-out for refrigerators/freezers for commercial use except for medical equipment (**point 11**), cascaded approach GWP150 in 2025, no F-Gases in 2030+;

(4) Moving to GWP150 in larger chillers (**point 15**), cascaded approach GWP 750 in 2027, GWP150 in 2030+.

These potential packages include the different options on compromise on **starting dates** that are far apart.

The impacts of these elements taken individually may be estimated as follows:

(1) Phase-out in medium voltage switchgear

Technical feasibility and market availability

The EP request an F-Gases phase-out limited to the first step of the prohibition cascade in the <u>medium-voltage</u> sector. Because the structure of this prohibition includes the cascade principle, the notion of ‘technically feasibility’ in relation to this prohibition is less relevant, as it is always possible to install a switchgear with a higher GWP if it is demonstrated that it is not feasible to install an F-gas free switchgear. Nonetheless, in this sector a number of F-gas free alternatives (e.g. mixtures of nitrogen and oxygen (“technical air”), ambient air, in combination with solid insultation) exist and are available from many (EU) manufacturers (see Annex I). They are also already frequently used in the grid.

A technical Commission report from 2020[1] found that air-insulated switchgear had a 40 to 80% market share in primary distribution installations where space and environmental factors are not an issue and concluded that alternatives would take two to five years (i.e. until 2026) to be available to cover the whole product range in medium-voltage switchgear. In the early years of the prohibition, for any specialised applications where natural alternatives should not be available, the cascade prohibition would allow the use of higher GWPs (first step of GWP1000/2000; second step unlimited, i.e. SF6).

The difference between the EP ask (no F-gases, but any natural alternative such as “air” - technical or ambient air - can be used), compared to the Council position (to go to GWP1) lies only in the question if the synthetic alternative fluoroketone, that is between GWP0 and GWP1, should also be allowed for the first step of the cascade, in addition to the widely available natural alternatives. Fluoroketone is propagated as an additional alternative by at least one company (ABB), and sometimes used in installed switchgear today. One advantage of this substance is that it can be used at atmospheric pressure, which reduces leakage. Certain industries have claimed that lifetime CO2-eq. emissions might be lower using synthetic

[1] https://climate.ec.europa.eu/system/files/2020-09/c_2020_6635_en.pdf

alternatives due to less use of material. For this there is an eco-design exemption possibility foreseen.

Given the abundance of the existing alternatives and the manufacturers providing them in the medium-voltage sector, there may not be so much of a use case for this substance. Where industries are critical about the proposal, they point out that for some specific circumstances alternatives are not available. However, as pointed out above, the cascade approach will imply that fluoroketone would only be prohibited if non-Fgas alternatives are available for the specific application and site of use. Where this is not the case, fluoroketone or any other insulation gas such as fluoronitrile mixtures with a GWP below 1000/2000 would still be allowed in the medium-voltage sector, and even gases with higher GWP if no offers are made.

Costs

The upfront investment costs for fluoroketone equipment may be slightly lower than those of natural options due to material use (estimate underlying the impact assessment €17.450 vs. €18.000). Given that natural solutions already have a large share of the market while fluoroketone does not, the cost impact for grid operators, passed to endusers, in case fluoroketone is not allowed in the first cascade step in the medium-voltage sector, would therefore be rather modest.

Emissions

The allowance/disallowance of the use of fluoroketone makes virtually no difference for climate-relevant emissions saved due to its low GWP (<1). However, fluoroketone is considered a PFAS substance and its breakdown products persist in the environment. It could therefore fall under a REACH PFAS restriction in the future. Already its current producer (3M) has announced that it will stop producing this substance and any other PFAS substances by 2025. It is unclear which company would be a future producer, should there be a demand, a gap that could be filled by Chinese companies. Taking this into account and given the progress made on natural alternatives in the medium voltage sector, commercial uptake of fluoroketone in this product range can be expected to be limited.

(2) Phase-out in small AC split systems (point 18)

Technical feasibility

A technical Commission report from 2020[2] on split air conditioning systems concluded that "it appears technically possible to avoid F-gases today in new single split air conditioning with a cooling capacity below 7 kW by using the refrigerant R-290 (propane), unless national legislation or codes prohibit its use. The latter has apparently prevented a large-scale rollout of such equipment in the EU so far. Propane units provide good energy efficiency and are available at a very modest price increase that would likely disappear if mass produced and marketed at large scale."

Further technological development and the updating of standards since then, in particular the adoption of standard IEC-60335-2-40 for heat pumps and air conditioning in 2022, do allow today for higher capacities to be used (e.g. up to 12kW and beyond)[3]. In addition, the safety requirement exemption, accepted by the EP, still allows the use of F-gases where this should be necessary due to any safety restrictions.

Energy efficiency and cooling capacity of propane split units compare favourably to conventional refrigerants, including the performance in warm climates, as demonstrated by

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[2] https://climate.ec.europa.eu/system/files/2020-09/c_2020_6637_en.pdf

[3] GIZ Report (June 2022). Can refrigerants with a GWP below 150 be used for split air conditioners in Europe?
https://www.green-cooling-initiative.org/fileadmin/user_upload/2022_Proklima_Split_AC_Assessment.pdf

e.g. the PRAHA project funded by the Montreal Protocol's Multilateral Fund (MLF)[4]. This was confirmed recently by a technical report by GIZ[5] proklima (2022). This conclusion was also supported by a position paper[6] on the use of propane by 25 research institutions from 17 European countries. This analysis was "supported by system efficiency comparisons carried out by using thousands of product data for systems from almost the entire EU market, which use either propane or other refrigerants."

Market availability and development

Since 2012, propane has been used in commercially available split air conditioners by some major Chinese and Indian manufacturers. The current theoretical production capacity (2019) for propane split air conditioning units is estimated at about 7 million units per year (UNIDO). The actual globally installed base is over 1 million units today, mainly in India (800 000) and China (latest information is that 300 000 units have been surpassed).

However, only a few split unit models with propane are currently available on the EU market. Given the technical readiness and available production capacity, the EU market entry seems to have been delayed mostly as a result of standards and codes restricting the use of propane unnecessarily until 2022 (see previous section above). According to the EU research community[6] "the components required for producing such (hydrocarbon, i.e. propane) heat pumps are available on the EU market. All of the basic research and development work to optimize the design of heat exchangers as well as compressors [..] has been done in the past 15 years. This has led to widely available components and design rules for scaling up capacities. [..] A transition time to propane for outdoor installations of 3-5 years and for indoor heat pump of 3-8 years seems to be realistic [to phase out F-gases], depending on the different applications and capacity ranges [of heatpumps]."

Furthermore, the researchers state that "the early announcement of clear and ambitious phase-out dates of synthetic refrigerants, taking different development time spans for different product classes (indoor/ outdoor/ monobloc/ split/multi-split/VRF) and application areas (residential/commercial/industrial) into account, [..] is a clear decision for environmental protection but also provides the industry with a long-term reliable perspective, allowing the focus to lie on further optimization rather than on adopting systems to new refrigerants every few years."

Industry is divided on the timelines and feasibility. While there is strong support from producers of equipment with naturals, others are critical and consider the need to use HFCs and HFO blends.

Costs

The GIZ[7] proklima (2022) study found that the cost implications for additional safety features for propane are minor, especially when considering higher efficiency products that already use electronic expansion valves. In their view, the cost effectiveness of switching to propane, from existing technology (R32), are favourable and would likely incur a only small incremental material cost. In all cases, the variation would be less than 1% of the retail price. Propane

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[4] PRAHA: Promoting Low GWP Refrigerants for Air-Conditioning Sectors in High Ambient Temperature
Countries.
http://www.multilateralfund.org/Our%20Work/DemonProject/Document%20Library/7610p2%20-%20PRAHA.pdf

[5] GIZ: Deutsche Gesellschaft für internationale Zusammenarbeit (German Agency for international cooperation)

[6] A Transition to Sustainable Heat Pumps – a Position Paper from the Scientific Community (2023) https://www.energy.kth.se/polopoly_fs/1.1239380.1678961980!/PositionPaper_ReviewFGas.pdf

[7] GIZ: Deutsche Gesellschaft für internationale Zusammenarbeit (German Agency for international cooperation)

would compare even more favourably in cost terms if lifetime costs associated with re-charging or topping-up of systems are accounted for. As HFC/HFO blends are not yet as established as propane, cost of such equipment is unlikely to be cheaper than propane installation, in particular in the early years.

Endusers will pay more for their alternative equipment initially (“upfront costs”), but this is more than compensated by energy savings during the lifetime of the equipment. The end users will benefit from cost savings according to the impact assessment. In fact, the “costs of technology change” that include both upfront investment and lifetime costs are strongly negative for this sector: -71 million €/ year in the period 2024-2036 (see impact assessment 6.2.1.1 and 6.3.5 as well as Table 40 in Annex A12.3). Similarly, abatement costs for this sector are negative: -43 € /ton CO2 eq (Table 46 in Annex A12.4 of impact assessment). These numbers are all based on the use of propane as alternative technology.

Emissions

The greenhouse gas emissions associated with propane (R290) will yield significant benefits, relative to conventional technology (R410A and R32). Total emissions have been determined as follows (GIZ, 2022):

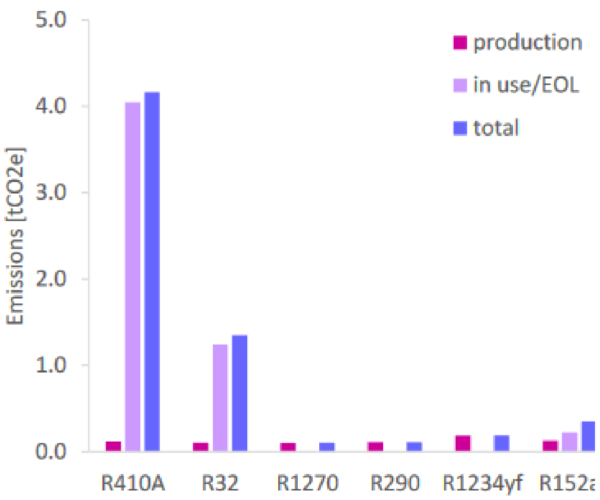

Figure 68: Production, lifetime and total emissions, using 100-year ITH GWPs

The emission impact of any measure to ban F-gases in a cascade with a GWP150 ban will depend on the uptake of small splits using a HFC/HFO blend with up to GWP150 under the Council approach . T

Overall, to the extent that the measure in 2030+ would reduce quota use in the sector of split heat pumps, it would free up quota to be used in another sector, so there will be no environmental impact.

(3) Phase-out in commercial fridges and freezers (point 11)

Technical feasibility and market availability

Natural alternatives (hydrocarbons and CO2) are commonly used technologies in this sector. In the last decade, a significant conversion from F-gases to propane and isobutane (both hydrocarbons) took place in this type of equipment. In 2021, there were 2.7 million plug-in hydrocarbon units in use in Europe (Shecco), most of which would fall into the point 11 category. Consequently, the main alternative considered for this sector in the impact assessment modelling was propane or isobutane (both hydrocarbons; 100% by 2030). The units are found to be particularly energy efficient and can also be linked to a water-loop in some cases. Pursuant to the current F-gas Regulation, the placing on the market of hermetic units for commercial containing refrigerants with a GWP>150 is prohibited since 2022.

There are many companies offering such equipment, and many among them are EU-based[8].

There could be some issues of availability of such equipment in the medical sector (only where it could be considered as “commercial use”) which might require up to five years of development. The package proposals that include point 11 would exempt this sector.

The HFC-HFO blends R454C and R455A (GWP 148) have been announced as potential options in this sector, however manufacturers seem not yet to offer standard products containing these refrigerants.

Costs

No extra cost is expected for this option as natural substances are the main alternatives anyway and more widely available (economies of scale) than any new HFC/HFO (blends) options that would still be possible under the Council approach. There was therefore no premium for investment costs for alternative equipment considered in the impact assessment. Cost of technological change (for equipment operators/endusers) as estimated in the impact assessment for the natural options would be -2.6 million € per year (i.e. costs savings due to better energy efficiency),Table 40, Annex 12.3 of impact assessment.

Emissions

As the standard equipment available today is already using mainly HFC alternatives, it is not expected that there would be a significant impact on emissions.

(4) Going to GWP150 in larger chillers (point 15)

Technical feasibility and market availability

Both air-cooled displacement and water-cooled displacement chillers are viable with GWP<150. The options include the natural alternatives water and ammonia that have available on the market for a long time, and more recently pure HFOs (e.g. HFO-1234ze) and HFO blends (e.g. R-454C, R-455A). For centrifugal chillers the viable options are CO2 and ammonia (established technologies), as well as pure HFOs (e.g. HFO-1234ze, HFO-1233zd). There have been significant recent efforts using the new HFO/HFO-blends options and new products are regularly coming to the market in these sectors. Principally, EPEE members seem to be okay with a GWP150 limit for larger chillers based on their position paper.

Costs

In the impact assessment, upfront investment costs for large displacement chillers using water/ammonia (€87,500 per unit) are considered somewhat higher than for HFO/HFC blends or R32 (€73,500 per unit), and conventional technology (R410A/R134a: €70,000 per unit). Similarly, for large centrifugal chillers, upfront costs with natural refrigerants were assumed to be €154,000 per unit vs. €141,400 per unit for HFC and HFO equipment. However, some additional costs arise from refrigerant initial and refill costs for the HFC and HFO equipment, which is not the case for equipment using natural alternatives. Cost of technological change (for equipment operators/endusers) are estimated to be 21 million € per year for displacement chillers, and -2 million € per year (costs savings due to better energy efficiency) for centrifugal

[8] EU companies offering refrigeration equipment using natural refrigerations include Advansor, AHT cooling systems, AREA cooling solutions, Arneg, Carel, Castel, Dorin, Epta, GEA, Fricon, Günther, TEKO, and Viessmann. In addition, there are EU component manufacturers such as Bizer, Danfoss, Embraco etc..

chillers (Table 40, Annex 12.3 of impact assessment). As these numbers assume a high use of natural alternatives, a ban of GWP150 that allows also for the HFC/HFO options would result in very moderate costs only.

Emissions

The impact assessment, based on expert opinion, assumes, even in the absence of a ban going to GWP150, an 85% and 99% use of refrigerants with GWP150 or lower by 2030 for displacement and centrifugal chillers, respectively. Emission reductions would therefore be limited.

(5) Compromises on starting dates that are far apart

(i) compromise starting date of **2028** (Council 2030, EP 2026) for **larger self-contained air conditioning and heat pumps** (point 17, “other self-contained”, GWP150)

Technical feasibility

In large self-contained equipment a move to GWP150 by 2028 seems achievable. Different such alternatives exist, both natural and HFO-based. The option to still use GWP750 where necessary further increases feasibility.

(ii) compromise starting date of **2029** (Council 2030, EP 2027) for **point 13** (Refrigeration equipment except chillers) with GWP150

Technical feasibility

Alternatives are available. Industry groups in their position papers (e.g. EPEE) pointed out that a prohibition in this sector with GWP150 would be feasible in this timeframe.

(iii) compromise starting date of **2031** (Council 2033, EP 2028) for **large split systems** (point 18, “split systems of a rates capacity of 200kW or more”, GWP150)

Technical feasibility

The COM 2020 report on split AC indicated that the technology transition has begun in this sector and that “several manufacturers are selling larger split AC with low GWP refrigerants [..] and that good progress is expected in the medium term”. A 2031 date would allow for eight years of development, testing and commercialization. 2031 would be after the general review allowing to reassess feasibility at a time nearer to the prohibition.

Costs

For all three (i)-(iii), the anticipation of a ban by one to two years is not expected to result in many extra costs. The costs of in particular the HFO-based alternatives are not likely to increase much beyond traditional higher GWP technologies, based on assumptions underlying impact assessment estimates.

Emissions

For all three (i)-(iii), a change of one - two years will not make a large difference of emissions, given the moderate size of the sectors and the inclusion in the quota system that is incentising low GWP technologies. There could be an emission saving of up to 2.5 million CO2 for point (i) until 2050. Emission savings for (ii) and (iii) would be lower.

SUMMARY OF THE FINDINGS

All compromise packages are

- Technically feasible;
- Do typically not represent significant additional costs to the end-user, and often reduce operative costs;
- Do not lead to significant new emission savings, because of how the quota system functions, but avoids the use of PFAS (in different sectors);

In addition, all options are considered to be fully compatible with Repower EU. In this context, the most relevant issue is point 18 (small split AC), which is part of Package A and D, as this sector includes heat pumps, whose growth is required to achieve the Repower EU targets. However, the additional 2030+ signal in this sector to avoid F-gases (in addition to the 2029 (air-to-air) and 2027 (air-to-water) GWP150 prohibition as already proposed by the Council) does not hinder this Repower EU development:

- New production capacities for heat pumps will be needed in any case, regardless of the technology. Similarly, existing constraints such as lack of installers and end-user uptake must be addressed, regardless of the refrigerant technology.
- Heat-pump manufacturers need a number of years for transitioning to alternatives, regardless if GWP150 (Council approach) or GWP0 (Compromise proposal, in the long run). The alternative technologies are available, but need to be scaled up. In the case of propane, the technology is more commercially available than is the case of HFC/HFO alternatives.
- EU heat pump manufacturers have a high market share in the EU and many have experience with refrigerant alternatives to F-gases and components using them (see Annex II). The phase-out of such F-gases can represent an opportunity for the EU heat pump value chain overall.
- As non-EU companies stand ready to enter the market with propane technology even with only a GWP150 in place, a signal of GWP0 would direct EU industry and better ensure to maintain their competitiveness in this sector. This is also of relevance globally, because all countries in the world will have to reduce their F-gas use under the Montreal Protocol.
- Propane heat-pumps would lead to energy-savings and therefore cost savings for the buyers and users of such heat pump equipment.

ANNEX 1 – Companies with Fgas-free alternatives in switchgear

Source: COP27 European Union Side Event on F-gases and SF6 Alternatives, Sharm el-Sheik, 10 November 2022

[Joint letter: Europe's major industry players call for phase-out of F-gases in switchgear (switchinggearsfornetzero.com)](switchinggearsfornetzero.com).

Annex 2 - Companies having natural refrigerant heatpumps in their portfolio

Source: ATMO Report (2023). Delivering today on EU F-gas, REPowerEU and PFAS Restriction with natural refrigerant heat pumps

https://atmosphere.cool/wp-content/uploads/2023/06/2023_ATMO_heat_pumps_report.pdf