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Working Paper

Refrigerants and Foam-blowing Agents in Household Refrigerating Appliances – Facts and Policy Recommendations

Oeko-Institut Working Paper 1/2018

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1. Introduction

Refrigerants and foam-blowing agents have a long history of being criticized for their environmental impact. In Europe, mostly natural refrigerants and foam-blowing agents (mainly cyclopentante and isobutane) are nowadays used in household refrigerating appliances. In other applications, (e.g. stationary or mobile air conditioning, heat pumps in other household appliances) or other parts of the world, however, hydrofluorocarbons (like R134a) with much higher global warming potential are still being used. Recently, a new generation of partly fluorinated (and partly chlorinated) hydrocarbons (so called HFOs) has been introduced and marketed by manufacturers of refrigerants and foam-blowing agents.

This fact sheet aims at providing a short overview of the historical development of refrigerants and foam-blowing agents, the claimed advantages and possible disadvantages / risks of HFOs, and concludes with some recommendations with regard to a possible regulation of household refrigerating appliances.

It has been prepared in order to provide background information and policy advice in the framework of the currently (November 2017) ongoing revision of the Commission Delegated Regulation (EU) No 1060/2010 (energy labelling of household refrigerating appliances) and Commission Regulation (EC) No 643/2009 (ecodesign requirements for household refrigerating appliances).

2. Developments in the past and today

Before 1993, chlorofluorocarbons (CFCs) have been used as refrigerants and foam-blowing agents in household refrigerating appliances. These substances have a high ozone depletion potential (ODP) and a high global warming potential (GWP). Due to their high ODP, they have been replaced by hydrofluorocarbons (mainly R134) that have a low ODP but still a high GWP. The GWP of these substances ranges between approx. 1'300 kg CO_{2e}/kg (R134a) and 10'200 kg CO_{2e}/kg (R12) (GWP 100).

From 1994 onwards, R134a has been increasingly replaced in Europe by halogen-free hydrocabons such as isobutane and pentane. These substances have no ODP and low GWP emissions (in the range of 3 to 25 kg CO_{2e}/kg). The rest of the world continued to use R134a.

Today, new synthetic halogenated hydrocarbons (non-saturated partly-fluorinated (and partly-chlorinated hydrocarbon, so-called hydrofluoroolefines, HFOs) have been introduced. Also European manufacturers are currently testing these new substances as foam-blowing agents instead of the currently most commonly used hydrocarbon pentane. These substances have no ODP and a GWP which is in the same range as isobutane and pentane.

The following table shows this development for Europe and the rest of the world (RoW).

Table 2-1: Historical development of refrigerants and foam-blowing agents in household refrigerating appliances

	Europe	RoW
Before 1993	CFCs (e.g. R12, R11) (high ODP and very high GWP)	CFCs (e.g. R12, R11) (high ODP and very high GWP)
1993 (in Europe: until 1997)	HFCs (mainly R134a) (low ODP but still high GWP)	HFCs (mainly R134a) (low ODP but still high GWP)
From 1994 onwards	Halogen-free hydrocarbons (e.g. isobutane, pentane, …) (no ODP and low GWP)	
Since approx. 2009	Also HFOs???	New synthetic halogenated hydrocarbons (non-saturated partly-fluorinated (and partly-chlorinated) hydrocarbons, so-called 'HFOs') (no ODP and low GWP)

Source: own compilation; GWP = Global warming potential, ODP = Ozone depletion potential, CFC = Chlorofluorocarbon, HFC = Hydrofluorocarbon, HFO = Hydrofluoroolefines

3. Drivers for the use of HFOs

One driver for a possible replacement of the currently used 'natural' foam-blowing agents in (European) household refrigerating appliances with the newly developed HFOs is the claimed positive effect on the energy efficiency of the appliances due to better insulating properties. Especially manufacturers of these substances use this claim for marketing purposes, also with a view to compensating for decreasing sales of other fluorinated hydrocarbons (due to their phase out because of the F-Gas regulation). BASF, Honeywell and Whirlpool, for example, advertise a 2 to 3% overall increase in energy efficiency of the household refrigerating appliances through the use of these substances.[1]

The announced improvements with regard to energy efficiency of refrigerating appliances are quite small though, and publicly available test results regarding the short- and long-term properties, the effects on the insulation efficiency and the necessary total amount of such foams are missing.

[1] https://www.basf.com/us/en/company/news-and-media/news-releases/2014/07/p-13-628.html

4. Disadvantages and risks

HFOs do not have an ozone depletion potential and their global warming potential is in the same order of magnitude as that of natural refrigerants and foam-blowing agents (halogen-free hydrocarbons, CO_2, etc.). However, they also pose substantial potential risks which should be taken into account in their overall evaluation:

- HFOs are potentially persistent[2] (they are persistent according to EPI Suite[3]). Persistent substances are problematic for the following reasons:
  - They can accumulate in the environment and reach concentrations above which they might have negative effects.
  - Once emitted into the environment they remain in specific environmental compartments (water, soil, sediment, air etc.).
  - Many persistent substances reach distant and so far untouched areas (through transport in the atmosphere and biosphere).
  - They may accumulate in the food chain and thus pose a risk also to human health.
- One known degradation product is trifluoroacetic acid (TFA) which is persistent and slightly toxic for plants. A higher concentration through accumulation might have negative effects.
- Type and amount of degradation products of most HFOs and thus their impact on environment and health are unknown and unexplored so far.[4]
- In the case of heat or fire, hydrofluoric acid is produced. This acid is toxic and strongly corrosive.
- Recyclers are currently prepared to handle appliances with halogen-free hydrocarbons or the previously used CFCs as refrigerant and foam-blowing agent. Further substances may introduce additional challenges for recycling (additional infrastructure, separation of waste streams, safety requirements, training demands, …).

[2] Persistence of a compound is typically expressed as degradation half-lives or degradation rate constants. The compartment-specific persistence is a sum of several degradation processes and, in open systems, loss processes due to transport from one environmental compartment to another.

[3] EPI (Estimation Programs Interface) Suite is a Windows®-based compilation of models to estimate the physical/chemical properties of substances and their behaviour in the environment.

[4] Regarding the HFOs and their degradation products, the German Federal Environment Agency (UBA) has initiated a research project which has just started (FKZ 3717 41 305 0)

5. Conclusions

With regard to

- the fact that there are existing and state-of-the-art, environmentally friendly natural refrigerants and foam-blowing agents allowing for highly efficient (household) refrigerating appliances,
- the fact that the energy efficiency improvements of HFOs as foam-blowing agent compared to pentane are rather small and (publicly available) tests about short- and long-term properties, the effects on the insulation efficiency and the necessary total amount of such foams are missing,
- the fact that there are alternative means to increase the insulation efficiency of refrigerating appliances (e.g. vacuum insulation panels, VIP, cf. technology roadmap household refrigeration appliances[5]),
- the known disadvantages and unknown risks of HFOs and their degradation products,
- the fact that HFOs are neither covered by Annex I of the F-Gas regulation (517/2014) and the respective requirements, nor affected by the Kigali deal[6] (inclusion of HFCs into the Montreal protocol to phase down their usage),
- the higher costs of HFOs which will act as a barrier for developing countries to phase out HFCs,
- the fact that HFO development will delay the deployment of natural refrigerants as most sustainable alternatives,
- and the precautionary principle,

we recommend

strict regulation of halogenated hydrocarbons as refrigerants and foam-blowing agents. We propose a ban of these substances in household refrigerating appliances.

[5] VHK/ARMINES: Technology Roadmap in preparatory/review study on Commission Regulation (EC) No. 643/2009 with regard to ecodesign requirements for household refrigeration appliances and Commission Delegated Regulation (EU) No. 1060/2010 with regard to energy labelling of household refrigeration appliances. Final Roadmap Report. http://www.ecodesign-fridges.eu/Pages/documents.aspx

[6] With the adoption of the Kigali Amendment to the Montreal Protocol in 2016, an essential milestone for climate protection was reached. The Kigali Amendment sets out a legally binding multilateral agreement to govern the production and consumption of hydrofluorocarbons (HFCs) and will hence provide a major boost to the prospects for climate-friendly refrigerants and accelerate innovation for sustainable technologies. This latest amendment to the Montreal Protocol will considerably contribute to the long-term goals of the Paris Agreement to hold the global temperature rise to well below 2° Celsius above pre-industrial levels and to pursue efforts to limit the increase in temperature to 1° Celsius. In addition to the global regulation, there is regulatory action at regional and national level to control HFCs.