HFOs:
the new generation of F-gases

Greenpeace Position Paper

October 2009

With the agreed phase out of CFCs and HCFCs under the Montreal Protocol, political work is now turning its attention to the strong negative impacts of HFCs on the climate and discussion is taking place on the next set of alternatives. The chemical industry is promoting new substances it calls 'Hydrofluoroolefins' or HFOs.

Chemically, HFOs are HFCs, but due to the negative connotations that HFCs have acquired, this new class of chemicals has been marketed under a different name. This is part of a marketing strategy to portray these new HFCs as having a low impact on the climate while glossing over their negative environmental effects. As set out below, these new HFCs have real and dangerous environmental and health impacts.

Greenpeace has four main arguments against HFOs, the fourth generation of F-gases:

I. **HFOs present an unnecessary risk to the environment and human health**

II. **HFOs are only a short-term fix**

III. **Natural refrigerants are the best available technology and offer the long-term solution; HFO development will only delay their deployment.**

IV. **Greenpeace does not want to see history repeating itself;** after three subsequent generations of destructive chemical products it is time to opt for the only acceptable alternative: natural refrigerants

Greenpeace seeks the phase out of all F-gases, which present a growing threat to the environment. Greenpeace is not against the development of alternatives, but until our concerns about HFOs can be proven otherwise, the precautionary principle should prevail. Safer, cheaper and readily-available alternatives already exist for all applications, and given this fact, we favour the deployment of natural refrigerant and oppose the continuing dependence on synthetic refrigerants.

In order to prevent dangerous climate change, global greenhouse gas emissions need to peak by 2015, and start declining rapidly thereafter, reaching as close to zero as possible by mid-century. In order to achieve these ambitious objectives Greenpeace will support every sustainable means of doing so, in line with the precautionary principle and therefore without compromising the health and vitality of our planet or future generations. Greenpeace will continuously assess the sustainability of new technologies based on newly-available information.

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I. HFOs present an unnecessary risk to the environment and human health

a. **HCFCs[1] are used to make HFO-1234yf**

This means that ozone-depleting and global warming chemicals that are soon going to be banned under the Montreal Protocol are the source of the refrigerants of the future. As opposed to natural refrigerant technology that is tried, tested and open for all to use and develop, the chemical details of HFO-1234yf are shrouded in secrecy. The details that we do know already make it very dangerous (see below). Additionally, the substances that are released into the atmosphere as a result of its production, or anything concerning its reproductive toxicity[2] is still uncertain.

b. **HFOs and other HFCs produce toxic by-products upon their production and decomposition**

When HFO-1234yf breaks down in the atmosphere it produces trifluoroacetic acid (TFA). In high-enough concentrations, TFA is toxic to aquatic ecosystems.[3] While TFA is a common by-product when other HFCs breakdown, HFO-1234yf produces **4 to 5 times as much TFA** than the same amount of HFC-134a does.[4] This means that if HFO-1234yf (and other HFOs) become the refrigerant of choice, the concentration of TFA in fresh water bodies around the world could increase dramatically, with unknown effects on ecosystems and human health, as TFA concentration approaching a milligram per litre may be toxic to some aquatic life forms.[5]

The Scientific Assessment Panel to the Montreal Protocol recently raised its concerns about HFOs including the possibility of its break down products being high GWP HFCs or even ozone-depleting substances, and of the potential for tropospheric ozone pollution formation.[6]

c. **Given that HFO-1234yf is flammable, the combustibility of this chemical are also of concern.**

Honeywell confirms that if a car using HFO-1234yf catches on fire, it releases hazardous substances such as hydrogen fluoride (hydrofluoric acid), which is toxic and can be lethal in unventilated spaces (e.g. tunnels, cars with no open doors or windows, etc.) [7] FIAT has calculated, that for every kilo of HFO-1234yf that is burnt, 702 grams of hydrofluoric acid is produced[8] (this has been confirmed by the Society of Automobile Engineers). Thus, a normal charge of HFO-1234yf (550 grams in a Pontiac car, 410 grams in an Opel Astra) would produce 385 grams (Pontiac) and 287 grams (Opel) of HF respectively, which is 118 grams per 1 cubic metre of air. This is an amount potentially lethal to a large number of people. It would greatly increase the potential number of casualties from car crashes, particularly in confined and unventilated areas (such as indoor parking lots and tunnels). This risk makes the use of HFO-1234yf unacceptable.

Greenpeace does not consider the flammability of a refrigerant an inherent impediment to its use. Flammable refrigerants in mobile air conditioners (MACs) are safe when used in equipment designed for their use, such as systems with secondary loops. However, should the MAC industry opt for refrigerants that are flammable, then hydrocarbons are a superior choice over HFO-1234yf. They are already widely used in MACs in Australia and the US.[9] Hydrocarbons are environmentally friendly, more efficient, much cheaper, and immediately available.

II. HFOs are only a short-term fix

d. **Greenpeace assessment indicates that HFOs - the new generation of HFCs - will not help to achieve the needed peak in greenhouse gas emissions by 2015.**

These new chemicals are not yet commercially, practically or environmentally proven, but what is already known about their environmental and health effects makes them unacceptably dangerous (see below).

e. **The marketing argument for HFOs is their low climate impact relative to older HFCs. Nevertheless, this does not reflect the economic and social reality**:

- HFOs can be used as a 'drop-in', which means they can be used in existing technology without fundamental system changes[10]
- HFOs are more expensive than the refrigerants that they will replace[11]

If used as a drop-in solution, the prohibitive cost would be a problem, especially in developing countries. During maintenance, the systems could easily be retrofitted with cheaper HFCs (e.g. HFC-134a in

mobile air conditioning). This would reverse the initial climate benefits of using a low-GWP HFC. Additional safety measures applied to the system to impede such misuse are likely to raise the system costs again.

So, while being introduced as a 'climate-friendly alternative' to HFCs, HFOs will keep the market open in both industrialised and developing countries for unlimited use of high-GWP HFCs, (e.g. HFC-134a with a 20-year GWP of 3830). Should HFCs face mandatory 'phase-down and phase-out' measures under the UNFCCC and the Montreal Protocol, the possibility of their continued use as easy replacements for very expensive HFOs will undoubtedly fuel an HFC black market.

f. **We need a long-term approach that prioritises the real solutions. There is no need for any new chemicals. Natural substances are available and technically and economically feasible.**[12]

There is no need for the continued use of HFCs or HFOs. To highlight this, Greenpeace recently published an updated edition of its *Cool Technologies: Working Without HFCs* report, which documents the existence of natural alternatives with even better technical performance in almost every sector. This report has been confirmed and lauded by a number of refrigeration experts.[13]

III. Natural refrigerants are the best available technology and offer the long-term solution; HFO development will only delay their deployment.

g. **Natural refrigerants are more energy-efficient than new HFCs**

As already well established in many sectors, natural refrigerants tend to have better efficiency than the new chemicals. The replacement by Coca-Cola, Unilever and others of HFC-units with hydrocarbons as well as with CO_2 has brought about significant energy gains,. Similar efficiency gains have been demonstrated in many supermarkets that have switched to CO_2 systems. For more information, see Greenpeace's *Cool Technologies: Working Without HFCs* report.

This trend has been continued by the use of CO_2 in MACs, in comparison to HFC-134a and HFO-1234yf. Tests by the German EPA show CO_2 as more efficient than HFC-134a in a standard vehicle at temperatures up to 35^{o}C[14]. Visteon testing shows similar results at temperatures up to 45^{o}C[15]. Tests done by OEMs under SAE have shown that MACs with CO_2 show better efficiency under all climates and in all world regions[16].

In addition to all this, it is well-documented that as a 'drop in' replacement, HFO-1234yf is less efficient than HFC-134a.[17,18,19,20]

h. **HFOs are taking attention and resources away from cheaper, more efficient and better-understood natural refrigerants.**

HFO-1234yf is now the sixth potential replacement to HFC-134a proposed by the chemical industry. Two of the earlier low-GWP HFC products proposed, DP 1 and Fluid H, had to be scrapped due to toxicity concerns, and all other subsequent options were rejected by the car industry. At the same time, outstanding questions and cause for skepticism around HFO-1234yf remain.

HFOs are not currently on the market and production readiness for the 2011 MAC directive deadline is questionable. Ongoing safety tests, remaining REACH analysis in the EU, and a missing SNAP approval in the USA will delay the start of serial production. OEMs presenting at the SAE World Congress April 2009 confirmed that toxicity tests are not yet finalised.

i. **HFO should not be allowed to obstruct the real solutions**

The marketing of HFOs also results in the suppression of the market-ready CO_2 systems. The automotive and chemical industries are undermining the deadline for the phase-out of HFC-134a (2011 for new models vehicles), which means HFC-134a will dominate the market for many years to come[21].

IV. Greenpeace does not want to see history repeating itself; after three subsequent generations of destructive chemical products it is time to opt for the only acceptable alternative: natural refrigerants

j. **"Those who cannot remember the past are condemned to repeat it."**[22]

One of the arguments against this new generation of chemicals is the unique history of F-gases. This has been characterised by the disregard of their dangerous chemical properties that led first to the depletion of the ozone layer, then to the warming of the climate, and potentially will now lead to other areas.

Low GWP and non-ozone damaging properties are not reason enough to support the new generation of HFCs or 'HFOs'. Other serious environmental and health risks from these HFOs make them potentially just as dangerous as their predecessors. The sorry track record of the chemical industry marketing CFCs, HCFCs and HFCs during the last 70 years should be a lesson for not accepting at face value any of the assertions of this sector regarding its new products. This means that governments should not base policies within the Montreal Protocol or the UNFCCC based on industry claims, but on truly independent testing of these products.

k. **HFOs are just the beginning.**

There is a whole family of these gases waiting to be rolled out, with untold environmental and health effects. New F-gases potentially containing chlorine (which is responsible for most of the ozone depletion in the stratosphere) are being tested. While scientists indicate that because of their short lifetime, these new chemicals wouldn't reach the stratosphere, there are certain to be unanticipated environmental impacts from increased chlorine in the atmosphere.

l. **Greenpeace does not support countries providing public financial support to HFO at the expense of funding natural refrigerants development and investment.**

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1 HCFC-225 ca (20 year GWP: 550, ODP: 0.07) and HCFC-225 cb (20 year GWP: 1700, ODP: 0.03) – US patent no. 7,470,828 B2 (December 30, 2008). Available from http://www.freepatentsonline.com/7470828.html

2 REACH evaluation – HFO-1234yf.

3 Boutonnet et al. (1999). Environmental risk assessment of trifluoroacetic acid" *Human and Ecological Risk Assessment*, 5(1), 59–124.

4 EPA Proposed Ruling on HFO 1234yf p. 11-12 – October 19, 2009. Available at www.epa.gov/ozone/downloads/NPRMHFO1234yf.pdf

5 IPCC/TEAP Special Report on Ozone and Climate, Chapter 2, p.22

6 Newman et al. (2009). HCFCs and HFCs: An Update from the Scientific Assessment Panel.

7 *Ibid.*

8 Monfortte R and Caretto L. (2009). FIAT: Safety Issues in the Application of a Flammable Refrigerant Gas in MAC Systems: the OEM Perspective. Copyright SAE International. (See table 9a).

9 The Australian company HyChill (www.hychill.com.au) and American company OZ technology (www.oztechnologyinc.com) provide hydrocarbon refrigerants for mobile air conditioning.

10 Thierry Vanlancker, DuPont Fluorocarbons Manager, Personal communication to Greenpeace, Berlin, 10 March, 2009.

11 Refrigerant costs of HFO-1234y could be more than 10 times higher than those of R134a- Report from the German Environment Ministry comparing costs of R744 vs. R1234yf: "Proposal for supporting Mobile Air Conditioning (MAC) for Cars with a very low GWP" (2008).

12 Colbourne D. (2009). Opportunities for the application of Natural Refrigerants, in the GTZ publication Natural Refrigerants; Pachai AC et al. (2009) Achieving the green dream by the use of natural refrigerants.

13 Daniel Colbourne (Refrigerants, Naturally! Secretariat), Alexander Cohr Pachai (Johnson Controls), Per Henrik Pedersen (Danish Technological Institute).

14 Umwelt Bundes Amt. (2009). Natural refrigerants – CO_2-based air conditioning system put to practical testing.

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[18] Meyer J. (2008). R-1234yf System Enhancements and Comparison of R134a; Visteon. Presentation prepared for SAE 2008 Alternative Refrigerant Systems Symposium, 10-12 June, 2008, Phoenix, AZ.

[19] Benouali J, Karl S and Petitjean C. (2008). A/C System Control Strategies for Major Refrigerant Options; Valeo. Presentation prepared for SAE 2008 Alternative Refrigerant Systems Symposium, 10-12 June, 2008, Phoenix, AZ.

[20] Ikegami T, Iguchi M, Aoki K and Iijima K. (2008). New Refrigerants Evaluation Results. Toyota, Honda, Nissan, Valeo joint presentation prepared for the VDA Alternative Refrigerant Winter Meeting, 13-14 February, 2008, Saalfelden, Austria.

[21] Goldstein M. (2009). Car makers fight EU ban on climate change chemicals. Reuters. Jun 23, 2009. Accessed at http://www.reuters.com/article/rbssConsumerGoodsAndRetailNews/idUSLN24261420090623

[22] George Santayana, The Life of Reason or The Phases of Human Progress: Reason in Common Sense.